City and County of San Francisco

Public Utilities Commission

HETCH HETCHY WATER AND POWER SYSTEMWIDE POWER STUDY

SVERDRUP & PARCEL AND ASSOCIATES, INC.
SAN FRANCISCO, CALIFORNIA

IN ASSOCIATION WITH

BOOKMAN-EDMONSTON ENGINEERING, INC.
SACRAMENTO, CALIFORNIA

AND

JORDAN/AVENT AND ASSOCIATES
SAN FRANCISCO, CALIFORNIA

AND

WOODWARD CLYDE CONSULTANTS
SAN FRANCISCO, CALIFORNIA

JUNE, 1981

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Hetch Hetchy water and
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SUMMARY OF FINDINGS

HETCH HETCHY WATER AND POWER

SYSTEMWIDE POWER AND WATERSHED FIRM YIELD STUDY

SUMMARY OF FINDINGS

General

The City and County of San Francisco, through its Public Utilities Commission, authorized a Study to determine the opportunities for additional power generation facilities within the Hetch Hetchy System, and in areas adjacent to the system. The authorization also included a Study to determine if the present system can provide a firm yield water supply of 400 million gallons per day, and to make recommendations to attain that yield. The Studies were performed by the engineering firm of Sverdrup & Parcel and Associates, Inc., in association with Bookman-Edmonston Engineering, Inc, Jordan/Avent and Associates, and Woodward Clyde Consultants. Their findings are reported in two volumes entitled, "Hetch Hetchy Water and Power, Systemwide Power Study" and "Hetch Hetchy Water and Power, Watershed Firm Yield Study". Subsequent to release of the reports, the Commission requested that additional information be developed to determine the effects of releasing river flows for rafting purposes.

Systemwide Power Study

The Systemwide Power Study investigated the opportunities for, and the feasibilities of, additional power developments within and adjacent to the Hetch Hetchy system. There are three projects which are recommended for construction. The recommended projects are listed below.

1. It is recommended that an additional 33.75 MW generating unit be installed at the existing Kirkwood Powerhouse. The two existing units are restricted in their generating capability by their size. If another generating unit is installed, it could use most of the water that is annually spilled at Hetch Hetchy Reservoir, and provide an average annual income of $1.691 million

based on projected 1986 prices. The project could be financed by a bond issue of $30 million. No further engineering studies would be required, and a negative environmental declaration would most likely suffice. It is recommended that the City initiate the design of the additional generating unit. This project is designated as Project No. 1 in the basic report.

2. It is recommended that the existing dam at the Hetch Hetchy Reservoir be raised by 50 feet. Because of the current size of the Hetch Hetchy Reservoir, the City will be unable to meet its projected water requirements beyond the year of approximately 1990 without penalizing the income derived from power generation. In order to alleviate the shortage, a study was made to raise the dam by 50 feet, a height selected for reasons of cost and environmental acceptability. The study showed that if the dam were raised by 50 feet, and a new generating unit were added to Kirkwood Powerhouse as described above, the City would not only increase the reliability of the water supply system at no cost to the taxpayer, but the projects would also generate an average annual income of $6.942 million based on projected 1986 prices. The two projects together could be financed by a bond issue of $142.5 million. It is recommended that the City initiate engineering studies for eventual construction of this project. The combined projects are designated as Project No. 2 in the basic report.

3. It is recommended that a new tunnel be constructed from Holm Powerhouse to Moccasin Reservoir where a new 63 MW powerhouse could be installed. During the Study, special emphasis was placed on projects that would provide both additional power generation and also improve the firm water supply of the Hetch Hetchy System. This project would best satisfy the above criteria. The new tunnel would be connected to the existing Mountain Tunnel so that when repairs are necessary in the 55-year old Mountain Tunnel, the waters from Hetch Hetchy Reservoir could be conveyed in the new

tunnel. The powerhouse, located at the edge of Moccasin Reservoir, would normally pass its discharge waters downstream of Moccasin Reservoir; however, during a severe drought some of the water could be diverted into Moccasin Reservoir on an as-needed basis. This project would allow the City to meet its future water requirements and provide an average annual income of $21.8 million based on projected 1988 prices. The project could be financed by a bond issue of $471 million. It is recommended that the City initiate engineering studies for the construction of this project. The project is designated as Project No. 9 in the basic report.

If 830 cfs of water is released into the Tuolumne basin from the project, it would combine with other released flows to yield about 1,000 cfs available for rafting purposes. If this release is made to allow 8 full hours of rafting during each day of June, July and August, the annual average income of $21.8 million would be reduced to $12.94 million. A summary of data is shown on Figure 1 as Project No. 9A, and the project data sheets are included in the report under Appendix A.

If the dam at Hetch Hetchy Reservoir is raised by 50 feet, additional waters would be available for power generation at Project No. 9. As a result, the average annual income of $21.8 million would be increased to $26.2 million. A summary of data is shown on Figure 1 as Project No. 9B, and the project data sheets are included in the report under Appendix A.

If the dam at Hetch Hetchy Reservoir is raised by 50 feet, and 830 cfs of water is released to allow 8 full hours of rafting during each day of June, July and August, the average annual income would be $17.253 million. A summary of data is shown on Figure 1 as Project NO. 9C, and the project data sheets are included in the report under Appendix A.

4. Adjacent to the Hetch Hetchy System, there are two forks of the Tuolumne River, the Middle Fork and the South Fork. The Study identified two possible projects that may be useful additions to the City's generating system. As a result of the report, the City has filed for Federal Energy Regulatory Commission preliminary licenses. These projects are described as Project No. 4 and Project No. 6 in the basic report.

5. As an adjunct to the Systemwide Power Study, the construction costs and power benefits of the Clavey Project and the Clavey-Wards Ferry Projects were updated to the same criteria used to evaluate the other projects for comparative purposes. These projects would be jointly financed, and the benefits shared, with the Turlock and Modesto Irrigation Districts. The City's share would be 50 percent and, based on the same criteria the Clavey Project alone would provide the City an average annual income of $39.753 million based on projected 1988 prices, and could be financed by a bond issue of $274 million as the City's share. The combined Clavey-Wards Ferry Projects would provide the City an average annual income of $42.525 million based on projected 1988 prices, and could be financed by a bond issue of $437.5 million as the City's share.

A summary table of econonmically viable projects is shown on Figure 1, which was presented to the public at the Public Utility Commission meeting on July 14, 1981.

Watershed Firm Yield Study

The Watershed Firm Yield Study investigated the watershed of the Hetch Hetchy system to determine the firm yield which the system can provide during periods comparable to the lowest precipitation to date, and to establish the system management necessary to yield a delivery of 400 million gallons per day to the San Francisco area.

When the Hetch Hetchy facilities were planned in the early 1900's by John R. Freeman, it was concluded that a water supply of 400 million gallons per day (mgd) could be developed by the Hetch Hetchy Reservoir with supplemental diversions from Eleanor and Cherry Creeks. The City of San Francisco continues to plan to supply that amount of water to the San Francisco Bay area. However, the drought of 1975-77 raised concerns about the capability of the Hetch Hetchy System to develop 400 mgd. The Watershed Firm Yield Study reevaluated the firm yield of the existing facilities based on run-off records up to 1978.

The Study revealed that a firm yield of 400 mgd can be developed, without dry year deficiencies, by the existing facilities of the Hetch Hetchy System and the City's exchange storage space in Don Pedro Reservoir. Since water is not diverted from Eleanor and Cherry Creeks into Hetch Hetchy Reservoir as originally planned, in order to obtain the 400 mgd it would be necessary to divert some water released from Lake Lloyd and Lake Eleanor into Cherry Creek, then to Early Intake and finally into Mountain Tunnel. However, this diversion from Holm Powerhouse would reduce the power generated in the system.

Alternatively, the water supply from Hetch Hetchy Reservoir during dry years could be increased if the Reservoir is enlarged. A nominal increase of 50 feet in the height of the dam would enlarge the storage capacity by about 100,000 acre-feet with very little increase in the maximum water surface areas. By such an enlargement, the yield of Hetch Hetchy Reservoir during dry years could be increased from about 270 mgd to about 310 mgd.

Table of Economically Viable Projects

Proj. No and Title	Bond Cost	Installed Capacity	Generation Millions of KWH	B/C Ratio	1st Year Net Income
1. Kirkwood Powerhouse Addition	$ 30.0 M	33.75 MW	49.5	1.51	$ 1.691 M
2. Raise O'Shaughnessy Dam plus Kirkwood Powerhouse Add.	$ 142.5 M	33.75 MW	177.2	1.54	$ 6.942 M
4. South Fork Tuolumne[1]	$ 91.5 M	15.2 MW	60	1.18	$ 1.56 M
6. Harden Flat[1]	105.0 M	22.0 MW	91	1.65	$ 6.483 M
9. Add'l Moccasin Powerhouse[2]	$ 471.0 M	63.0 MW	440	1.51	$ 21.8 M
9A. Add'l Moccasin Powerhouse[2,3]	$ 471.0 M	63.0 MW	383.8	1.31	$ 12.94 M
9B. Add'l Moccasin Powerhouse[2] Operated in Conjunction with Project No. 2	$ 471.0 M	63.0 MW	476.6	1.61	$ 26.209 M
9C. Add'l Moccasin Powerhouse[2,3] Operated in Conjunction with with Project No. 2	$ 471.0 M	63.0 MW	420.04	1.41	$ 17.253 M
Clavey Project*[2]	274.0 M	150.0 MW	354	2.41	$ 39.753 M
Clavey-Wards Ferry Project*[2]	$ 437.5 M	200.0 MW	442	1.96	$ 42.525 M

* Shown for comparative purposes. Figures based on City's 50% interest in project.

1. Project Nos. 4 and 6 are mutually exclusive.

2. Project No. 9, 9A, 9B, 9C, Clavey Project and the Clavey-Wards Ferry Project are mutually exclusive.

3. Provides 830 cfs instream release for white water boating 8 hours/day for 90 days a year.

FIGURE 1

HETCH HETCHY WATER AND POWER
SYSTEMWIDE POWER STUDY

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SECTION 1

SUMMARY

SECTION 1

SUMMARY

This study was authorized by the City and County of San Francisco, through its Public Utilities Commission, to determine the opportunities for additional power generation facilities within the Hetch Hetchy system, and in areas adjacent to the system. The authorization also included a study to determine if the present system can provide a firm yield water supply of 400 million gallons per day, and to prescribe recommendations to attain that yield.

This volume contains the recommendations for additional power generation projects that appear logical and beneficial for the City and County of San Francisco. The report describing the study to determine the firm yield water supply is in a separate volume entitled, "Watershed Firm Yield Study".

This systemwide power study first identified numerous potential candidate projects. These potential projects were screened by calculating preliminary benefit-cost ratios. Those determined to be logical additions to or extensions of the Hetch Hetchy system were carried into the conceptual stage. Special emphasis was placed on projects which would not only provide additional power generation, but could also improve the firm water supply of the Hetch Hetchy system. Ten projects were carried into the conceptual stage. However, three of the ten projects are variations of one basic scheme. These variations were included to assure that the most favorable concept of increasing both water and power delivery was found.

Site reconnaissance investigations were performed at each project area to obtain geological opinions and to formulate environmental checklists. Based on past records, available in various publications, preliminary

hydrological studies were performed; and optimum dam heights were selected for those projects not constrained by other factors.

Conceptual drawings and benefit-cost ratios were developed for each project that was carried into the concept stage.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

Based on the studies described herein, the following conclusions and recommendations are made:

1. It is recommended that an additional generating unit be installed at Kirkwood Powerhouse. This project is described in Section 7 as Project No. 1, Kirkwood Powerhouse Addition. The benefit-cost ratio is 1.51; and would yield a net income of $1.691 million in 1986, the projected year of first commercial operation.

2. It is recommended that additional studies and foundation exploration be initiated to determine the optimum method of raising O'Shaughnessy Dam by approximately 50-feet. The raising of O'Shaughnessy Dam, coupled with the additional unit at Kirkwood Powerhouse, is described in Section 7 as Project No. 2. The combined projects have a benefit-cost ratio of 1.54 if benefits are derived from the sales of power only. This project would yield a net income of $6.942 million in 1986, the projected year of first commercial operation. Raising O'Shaughnessy Dam would provide an additional 100,000 acre-feet of water storage that, according to present projections, must be delivered from the Hetch Hetchy system by the year 1990. The benefit-cost ratio for the combined electrical sales revenue and the value of water would be 2.48, and the net income from the sales of power plus the value of water would be worth $19.042 million in 1990.

3. It is recommended that a Federal Energy Regulatory Commission preliminary permit be obtained for the South Fork Tuolumne Project. This project is described in Section 7 as Project No. 4. The benefit-cost ratio is 1.18. The preliminary permit will allow the City and County of San Francisco additional time to determine if this project will be a desirable addition.

4. It is recommended that a Federal Energy Regulatory Commission preliminary permit be obtained for the Harden Flat Project. This project is described in Section 7 as Project No. 6. The benefit-cost ratio is 1.65. The reason for the preliminary permit is the same as for the South Fork Tuolumne Project.

5. It is recommended that additional studies and foundation exploration be initiated for Project No. 9, Additional Moccasin Power Plant. This project will allow the water presently being discharged from the Holm Powerhouse to be conveyed to the edge of Moccasin Reservoir, where a new powerhouse can be constructed. The new powerhouse should be arranged to allow its discharge water to enter Moccasin Reservoir during drought periods. This project has a benefit-cost ratio of 1.51 and would yield a net income of $21.8 million in 1988, the projected year of first commercial operation. This project is favored over similar projects described herein. It is favored over Project No. 7 because it would place the powerhouse adjacent to the existing Moccasin Powerhouse for operational convenience, and it would also be located within Moccasin Village where policing activities could be minimal. It is favored over Project No. 8 because of the benefit-cost ratios.

6. The studies indicate that a pumped storage scheme in the vicinity of Moccasin would not be economically beneficial for three reasons: (1) the geology of the area, (2) the transmission losses that must be absorbed to transmit power to and from a substation having adequate capacity, and (3) the presently unfavorable ratio between the energy rates of on-peak and off-peak electrical power. A typical pumped-storage scheme is described in Section 7 as Project No. 10, Marshs Flat Pumped Storage Scheme. It is recommended that the study be updated and reviewed when off-peak power becomes available at a reasonable rate.

Table of Recommended Projects

	Project Number and Title	Bond Cost	Cap.	B/C Ratio	1st year Net Income
1.	Kirkwood Phse Addition	$ 30.0 M	33.75 MW	1.51	$ 1.691 M
2.	Raise O'Shaughnessy Dam plus Kirkwood Phse Add.	$ 142.5 M	33.75 MW	1.54	$ 6.942 M
	Including Water Benefits after 1990				$ 19.042 M
4.	South Fork Tuolumne **	$ 91.5 M	15.2 MW	1.18	$ 1.56 M
6.	Harden Flat **	$ 105.0 M	22.0 MW	1.65	$ 6.483 M
9.	Additional Moccasin Phse *	$ 471.0 M	63.0 MW	1.51	$ 21.8 M

* Project No. 9, Additional Moccasin Powerhouse will allow the City to meet its water commitments up to 400 MGD by providing a facility that can add to the water supply at Moccasin Reservoir on an as - needed basis. It will also provide a tunnel that can be used for water supply purposes so that the 55 - year old Mountain Tunnel could be repaired; and thereafter, the two tunnels could be adequately maintained without disrupting the water supply to the City.

** Project No. 4 and No. 6 are mutually exclusive. Recommendation is to apply for preliminary FERC permit to allow further studies.

Proposed Schedules of Recommended Projects

Project No. 1

Kirkwood Powerhouse Addition

Bond Sales, Engineering	1981 - 1983
Equipment Procurement and Construction	1983 - 1986

Project No. 2

Raising of O'Shaughnessy Dam and Kirkwood Powerhouse Addition

Engineering Investigation and Report	1981 - 1982
Bond Sales, Final Engineering	1982 - 1983
Construction	1983 - 1986

Project No. 9

Additional Moccasin Powerhouse

Engineering Investigation and Report	1981 - 1982
Bond Sales	1982
Final Engineering	1982 - 1984
Equipment Procurement and Construction	1984 - 1988

Note: All dates are to mid-year.

SECTION 3

INTRODUCTION

SECTION 3

INTRODUCTION

3.1 Authorization:

This Systemwide Power Study of the Hetch Hetchy system is authorized under the terms of an Agreement dated March 11, 1980 between the Public Utilities Commission of the City and County of San Francisco and Sverdrup & Parcel and Associates, Inc. Notice of certification of the contract by the Controller was received on April 9, 1980.

3.2 Scope of Study and Report:

The services to be performed by the Engineer, under the Agreement, are to make studies and prepare a report on the opportunities for, and the feasibility of, additional power generation facilities within, and adjacent to, the Hetch Hetchy system. The study is to include the development of new conventional facilities, pumped storage, uprating of existing equipment and the addition of new units at existing facilities. At the time of this study, a companion study was being performed to determine the capability of the Hetch Hetchy system to deliver 400 million gallons of water per day to the Water Department of the City and County of San Francisco. In this respect, several of the projects described herein have been studied not only for their power generating aspects, but also for their capability to provide a more dependable water supply for the City and County of San Francisco.

Numerous projects were evaluated for their practicality and preliminary benefit-cost ratios were determined. Those projects that appeared to have favorable preliminary benefit-cost ratios and a good

chance for completion were carried into the second study phase. The second phase consisted of developing concept sketches, making site visits, obtaining a geologic opinion, and developing a checklist of environmental impacts and concerns.

By agreement with the staff of the Public Utilities Commission, those projects that were being considered for development by its own engineering department were excluded from this study. Those projects are as follows:

a. Fishwater turbine at O'Shaughnessy Dam.

b. Power plant at Moccasin Dam.

c. Pumping Station in Cherry-Eleanor Tunnel.

SECTION 4

EXISTING FACILITIES

SECTION 4

EXISTING FACILITIES

4.1 Hetch Hetchy Reservoir:

The major feature of the Hetch Hetchy system is the reservoir which was created by the construction of O'Shaughnessy Dam. Initial dam construction was completed in 1923. The dam was raised to its present elevation of 3812 feet in 1938, creating a maximum storage capacity of 360,360 acre-feet. The dam is a concrete gravity-arch structure, approximately 430-feet high, with a total crest length of 910 feet.

4.2 Canyon Power Tunnel:

Other than the water released for fish and recreational purposes and the water spilled at O'Shaughnessy Dam during periods of high runoff, water is diverted into the Canyon Power Tunnel which is approximately 10.5 miles long. The tunnel cross-section consists of a 14-ft. 6-inch horseshoe shape which is generally unlined. From the tunnel exit portal, the water is conveyed by a steel penstock on a severe slope to Kirkwood Powerhouse.

4.3 Robert C. Kirkwood Powerhouse:

The Robert C. Kirkwood Powerhouse is located on the Tuolumne River near the Early Intake village. The powerhouse began commercial operation in 1967, and consists of two vertical shaft impulse turbines connected to generators. Each generator is rated at 33,750 kW for a combined plant capacity of 67,500 kW. This powerhouse contains a bypass valve capable of passing essential flows through the Hetch Hetchy system in the event one or both of the turbines are shut down.

4.4 Early Intake Diversion Dam:

Completed in 1924, the Early Intake Diversion Dam diverted the waters released from O'Shaughnessy Dam into the Mountain Tunnel. Since completion of Kirkwood Powerhouse, water has been directly diverted into Mountain Tunnel. There is a provision for discharging water directly into the Tuolumne River from the powerhouse and utilizing the former function of the Early Intake Dam. Early Intake Dam is a concrete arch structure, approximately 81-feet high, with a crest length of 262 feet. It creates a reservoir of approximately 155 acre-feet which receives releases from Hetch Hetchy Reservoir and the runoff from approximately 29 square miles of drainage area below the Hetch Hetchy Reservoir.

4.5 Mountain Tunnel:

Completed in 1925, Mountain Tunnel conveys the water approximately 19 miles to Priest Reservoir. The tunnel is about 60-percent lined, with a horseshoe-shaped cross-section.

4.6 Priest Dam and Regulating Reservoir:

Completed in 1923, the Priest Regulating Reservoir regulates the flow from Mountain Tunnel for use at the Moccasin Powerhouse. The reservoir was created by the construction of Priest Dam, an earth and rockfill structure. The dam has a height of approximately 160-feet at its maximum section and a crest length of 1,160 feet. Due to questions regarding structural integrity during earthquakes, the State of California Department of Dam Safety has directed that the reservoir not be completely filled. The City is allowed to fill the reservoir to elevation 2210, which corresponds to a storage capacity of 1055 acre-feet.

4.7 Moccasin Powerhouse:

Moccasin Powerhouse is served from Priest Reservoir through a one-mile, 13-foot concrete-lined horseshoe tunnel and two steel penstocks approximately 5200 feet in length. The powerhouse consists of two vertical shaft impulse turbines connected to generators, each rated at 45,000 kW, for a combined plant capacity of 90,000 kW. This powerhouse also contains bypass valves capable of passing essential flows in the event one or both of the turbines are shut down. The powerhouse discharges enter the Moccasin Reservoir. This powerhouse was completed in 1969 as a replacement for an older powerhouse that had been operating since 1925.

4.8 Moccasin Dam and Reservoir:

Completed in 1929, the Moccasin Dam and Reservoir is used to divert the water into Foothill Tunnel on its way to the City. The reservoir was created by constructing a dam on Moccasin Creek. The dam is an earth and rockfill structure, having a height of approximately 58 feet at the maximum section, and a crest length of 855 feet. The reservoir has a capacity of 550 acre-feet. Discharges from Moccasin Powerhouse, in excess of the capacity of Foothill Tunnel, are spilled over the spillway into Moccasin Creek and into Don Pedro Reservoir which is jointly operated by the Turlock Irrigation District and the Modesto Irrigation District. The City retains certain flood control storage rights of Don Pedro Reservoir.

4.9 Lake Eleanor Dam and Reservoir:

Completed in 1918, this reservoir was the initial storage development of the Hetch Hetchy system. Discharges from the lake were first conveyed via the Lower Cherry Aqueduct to a now abandoned

powerhouse on the Tuolumne River, near Early Intake. Lake Eleanor Dam is a concrete dam having a height of 60 feet. The storage capacity of the reservoir is 27,100 acre-feet.

4.10 <u>Lake Lloyd and Cherry Valley Dam</u>:

Completed in 1956 on Cherry Creek, the Cherry Valley Dam is a rockfill dam having a maximum height of 315 feet and a crest length of 2,600 feet. Lake Lloyd has a capacity of 268,800 acre-feet and the water is used primarily to serve Holm Powerhouse. A 10-ft., 10-inch horseshoe diversion tunnel connects Lake Lloyd with Lake Eleanor so that during the short periods that Lake Lloyd is lower than Lake Eleanor, water can be diverted from Lake Eleanor to Lake Lloyd. A gating system is provided to prevent flows in the reverse direction.

4.11 <u>Cherry Power Tunnel</u>:

Water is conveyed from Lake Lloyd to the Holm Powerhouse through the Cherry Power Tunnel which is approximately 5.6 miles in length. The tunnel is a generally unlined 12-ft., 6-inch horseshoe-shaped section. The water is then conveyed by a steel penstock, approximately 6,800 ft. long, to Holm Powerhouse.

4.12 <u>Dion R. Holm Powerhouse</u>:

The Dion R. Holm Powerhouse is located at the confluence of Cherry Creek and Granite Creek. The powerhouse was completed in 1960 and contains two vertical shaft impulse turbines connected to generators, each rated at 67,500 kW, for a combined plant capacity of 135,000 kW.

4.13 <u>System Map</u>:

The Hetch Hetchy system map is shown on Plate 1. The map shows the system's general relationship with the Stanislaus National Forest, Yosemite National Park and the City and County of San Francisco.

SECTION 5

PROJECT FORMULATION

SECTION 5

PROJECT FORMULATION

5.1 General:

The purpose of this report is to identify the potential hydropower project additions to the Hetch Hetchy system; including the development of new hydropower projects, the addition of new units to existing facilities, and the possible uprating of existing units. In formulating a potential project site, flow-duration and geographical data were used, and significant site-related features and constraints were considered. For studies of additions to existing facilities, the power generation schedule, reservoir operation data, reservoir area capacity data, tunnel flow test data, and power curves of the existing facilities were used.

5.2 Project Evaluation:

To select the more feasible potential projects, a preliminary screening process was applied. Numerous potential projects and concepts were analyzed to determine their power potential, revenues and costs. Preliminary benefit-cost ratios were calculated. Based on these benefit-cost ratios with considerations on power system planning, and water yield requirements in the future, ten projects were selected for more detailed study.

For the ten potential projects selected, basic data, benefits and costs were refined. Site visits with geologists and environmental specialists were made to the more promising projects, to acquire geological opinions and environmental checklists.

5.3 Theoretical Power Potentials:

In the evaluation of power potential for any given site, the available flow data was extracted from various sources, and the head at which the facility would operate was determined by acknowledging existing limitations or by optimizing the height of a dam.

a. Design flow: For new projects, a flow-duration curve was plotted using data from the USGS publication, "Surface Water Supply of the United States". Seasonal high flows, having low frequencies of occurrence, were not considered. A flow corresponding to 15% exceedence was generally used as the design flow for projects that are essentially run-of-river projects, based on judgement after studying the shape of the flow-duration curves. For projects which studied the addition of new units to existing facilities, the present design flows and load factors were adjusted to determine the possibility of operating the plants more nearly as peaking plants. The use of available excess spillage at dams were investigated for possible power generation.

b. Average operating heads: For a new site, the dam height was established by optimum analyses. The average operating head of a new site was assumed to be the difference between normal reservoir pool elevation and tailrace elevation (or center line of the nozzles of an impulse turbine) minus expected head losses. For additions to existing facilities, the existing average operating heads were used.

c. Load factor: Load factors were established for each individual potential project from either the flow duration curve or past generation schedules.

d. Potential power and energy: The power potential in kilowatts was calculated from the following formula:

$$kW = \frac{QHe}{11.8}$$

Where: Q = estimated design flow in cfs
H = average operating head in feet
e = overall plant efficiency of 0.85

The average annual energy (E), in kWh, was calculated from the following formula:

E = kW x load factor x 8760

Where: 8760 = number of hours in a year.

5.4 Controlling Criteria or Constraints

A major constraint on potential project development is the project location. As shown on Plate 1, Location Map, most of the projects are located within the boundary of the Stanislaus National Forest and the Yosemite National Park. Potential sites such as Harden Flat and Marshs Flat, would require the purchase of land from private owners.

5.5 Evaluation of Existing Transmission Lines:

In evaluating the capability of existing transmission lines to carry additional loads, it was found that the critical link is the Moccasin - Warnerville 230 kV Lines #5 and #6. If one of these lines is required to carry the full load of all of the conventional hydroelectric projects described herein; the system would be inadequate. However, if the loads are shared between the two 230 kV lines and 115 kV Lines #3 and #4, the present transmission system would be adequate to carry the additional

load. Therefore, only the costs for constructing a transmission line from each project location, to the existing transmission system have been added to each project.

For the Marshs Flat pumped-storage scheme, a new 500 kV transmission line would be required. It was judged that the pumping power would be tapped from Pacific Gas and Electric's Tesla Substation near Tracy. The cost of this transmission line is included in the estimates.

5.6 Potential Environmental Impacts:

During construction of the proposed additional facilities, there will be short-term environmental impacts. Following construction, long-term environmental effects could also be associated with the operation and maintenance of facilities. This report evaluates, using an environmental checklist, general environmental effects of each of the projects. The following subject areas have been evaluated: Land use compatibility; special use designations; vegetation; wildlife; hydrology; water quality; noise; socioeconomics and visual resources.
For each of these subject areas, three types of potential environmental impacts have been identified:

- Insignificant or minor impacts, which are those effects not considered to be significantly adverse.
- Mitigable impacts, which are those effects which could potentially be reduced to acceptable levels by design or other measures.
- Potentially significant impacts, which are those effects which could be significantly adverse.

These general impacts have been identified for each project, as shown in Section 7. The types of effects that have been evaluated for each subject are briefly discussed as follows:

a. Land Use Compatibility

This topic pertains to the compatibility of proposed additional facilities with the existing land use at and surrounding the project site. At sites that are already developed for hydroelectric power generation, additional facilities would likely be compatible. At sites presently used for other purposes (e.g., recreation, commercial or residential development), hydroelectric facilities or spoils disposal may not be compatible.

b. Special Use Designations

These refer to areas, both instream and offstream, that have been given special use designations by State or Federal agencies. They include the Yosemite National Park; the U.S. Forest Service RARE II further planning areas, which are located along the Tuolumne River from Lumsden Campground to Don Pedro Reservoir; the candidate Wild and Scenic River portion of the Tuolumne River from O'Shaughnessy Dam to Early Intake; and the designated City of Berkeley recreational camp.

c. Vegetation

This topic refers to general loss of habitat and destruction of unique vegetation communities. Other more detailed site-specific studies would be required to determine the potential for destruction of proposed or recommended threatened and endangered species in the study area. (Whitney sedge, Fawn lily, Mariposa parsnip, Southern mule ear clarkia, Shaggy lupine, or Red Hills soap root).

d. Wildlife

This refers to the temporary disturbance to wildlife during construction, and the potential for permanent alteration or loss of terrestial or aquatic habitat.

e. Hydrology

This topic pertains to the potential reduction in downstream flow accompanying certain proposed reservoir or tunnel diversion projects, which could affect existing downstream uses such as fishing or whitewater rafting.

f. Water Quality

This refers to the temporary alteration in downstream water quality during construction.

g. Noise

This refers to the temporary construction-related effects of potential blasting, truck hauling and equipment operation.

h. Socioeconomics

This pertains to the disruption or loss of recreational business, and the necessary relocation of homes and businesses which could accompany certain reservoir projects.

i. Visual Resources

This refers to the alteration of recognized viewsheds, which have unique scenic or recreational value, due to tunnel spoils disposal or construction of roads and surface facilities.

It should be noted that at this early phase of project planning, only general environmental effects can be identified. More detailed site-specific analyses would be required for each of the subject areas should a viable project be selected for further study. Other more

detailed investigations, e.g., cultural and archaeological resources, would also be required. In adddition, the permitting and licensing requirements of several County, State and Federal agencies would have to be considered.

5.7 Geological Conditions.

Depending upon the location and type of the proposed additional facilities, geological and geotechnical factors could be significant. The regional geologic conditions for the portion of the Hetch Hetchy project being evaluated range from vertical-walled deep canyons in massive granitic rock at the upper facilities of the system, to steep, but more deeply weathered, metamorphic terrain in the vicinity of Moccasin Power Plant. In between these areas, the geology is a combination of weathered granitic and metamorphic rock in rolling intercanyon areas, and fresh exposures of these rock types in the steep-walled river canyons. Granitic rock predominates in the upstream one-third of the Mountain Tunnel; metamorphic rock predominates in the downstream two thirds.

The types of geotechnical and geological factors evaluated for the proposed additional facilities were slope stability, depth of weathering, soil and rock foundation conditions, tunnelling conditions, spoil areas, and borrow materials. Information used in the evaluations consisted of available data on existing project facilities, published and unpublished geologic literature, and field visits to the proposed sites.

SECTION 6

FINANCIAL FEASIBILITY

SECTION 6

FINANCIAL FEASIBILITY

6.1 General

The feasibility of each project is determined by comparing the benefits and costs of the project over its useful life. The beneficial life of a hydroelectric facility is normally assumed to be 50-years; however, the analyses herein presented assumes a 40-year repayment period on the bonds, thereby yielding conservative results. Due to the present inflationary trends in the cost of electric power and the cost of construction and wages, it is deemed practical to escalate the cost of construction to the midpoint of the projected period of construction, and the revenues and operating expenses to the first projected year of commercial operation. It can be conservatively stated that if the first year of operation shows a positive benefit-cost ratio, the project will prove beneficial for the remainder of the project life. If escalation of revenues for the full life of the project is considered, the benefit-cost ratios stated herein would no doubt improve dramatically. However the act of predicting a probable escalation rate for the next fifty years appears presumptious; therefore, the projects have been evaluated based on the projected benefits of the first year of commercial operation. Upon review of numerous published sources, it is projected that near-term construction costs will escalate at an annual rate of 8-1/2%, and that the rates for electrical energy will esaclate at least at an annual rate of 11%. A description of the methods and assumptions that were utilized in this study is given below:

a. Capital Costs:

1. The estimated project costs were based on price levels experienced during the fall of 1980, escalated by an annual escalation rate of 8-1/2%. The annual escalation rate was determined by projecting the cost trends experienced during 1974-1980, as summarized in the March 13, 1980 issue of the Engineering News Record.

2. A 15% contingency factor was added to each project's estimated total direct cost to allow for unforeseen construction items to yield the total construction cost.

3. A variable Engineering and Administration allowance was added to each project's total construction cost to allow for permit applications, administration, engineering, and construction surveillance. The percentage allowances were as follows:

Total Construction Cost	Percentage Added
Up to $50 million	17.5%
$50 to $100 million	15.0%
Over $100 million	12.5%

4. Project financing was assumed to be through the issuance of bonds maturing over a period of 40 years beginning with the first year of commercial operation of the projects. Therefore, a sum equal to the anticipated interest during construction has been added to each project's total project cost.

5. A reserve fund equal to one year's debt service has been added to the total investment cost, in keeping with normal bond issue requirements.

6. A financing expense of 1% of the total financing cost has been added to the total investment cost to allow for bond issuance expenses.

7. A working capital sum of 0.2% of the financing cost has been added to each project.

b. Project Annual Costs:

Project annual costs were estimated for a 40-year bond repayment and amortization period, operation and maintenance, administrative and general, insurance, and interim replacement costs for each project.

1. The amortization and interest payment period was assumed to be 40 years even though the service life of each project is estimated to be 50 years. An annual interest rate of 9% was assumed for the study, based on the bonding capability of the City and County of San Francisco. The amortization factor was calculated using the following formula:

$$\text{Interest and Amortization Factor} = \frac{i}{(1+i)^{n}-1} + i$$

$$= 9.296\% \text{ of investment cost}$$

Where: i = annual interest rate = 9%
n = amortization period = 40 years

The interest and amortization factor has been applied to the total bond issue less the credit for the interest on the reserve fund. For this analysis, it has been assumed that the interest on the reserve fund equals the 9% interest on the bonds since the reserve fund can be placed in U.S. Treasury accounts.

2. Operation and Maintenance costs were estimated based on historical Hetch Hetchy production expenses. It was reported that the Hetch Hetchy production costs in 1977 were $5.19 per installed kW, and this value compares favorably with the historical data compiled by the Federal Energy Regulatory Commission of the U.S. Department of Energy in their publication DOE/FERC - 0031, Hydroelectric Power Evaluation. These costs were escalated at the annual rate of 8% to the year when it is projected that each project will commence operation.

3. Replacement costs, which account for replacement of worn parts and rehabilitation of structures have been assumed to be 1.4% of the power plant costs. This value was derived from the Hydropower Cost Estimating Manual, May 1979, by the U.S. Corps of Engineers.

4. The administrative and general costs have been assumed to be 39% of the operation and maintenance costs in accordance with the Federal Energy Regulatory Commission publication, DOE/FERC - 0031, Hydroelectric Power Evaluation.

5. The cost of insurance has been estimated to be 0.1% of the total construction cost.

6. Property taxes have not been applied to those projects on the present Hetch Hetchy Water Supply system since those projects have historically been tax-exempt. Those projects outside of the Hetch Hetchy system, or those projects that would utilize the water stored at Lakes Lloyd and Eleanor, have been debited with a tax rate of 6% of the net profit of the operations since there appears to be precedence for this tax rate.

c. Annual Benefits

1. Power benefits. Revenues from the sales of electrical power were based on the report by the Pacific Gas and Electric Company to the State of California Public Utilities Commission for the third quarter of 1980, escalated to the projected year of first commercial operation of each project. In determining the escalation rate, various publications were researched for the projected increase in distillate and residual fuel oil. One source of information was the Long-term Forecast of Economic Activity, Autumn 1980, by the Pacific Gas and Electric Company's Economic and Statistics Department.

This source forecasts an increase of 20% in the price of distillate fuel oil in 1981, and again in 1982, and 11.5% annual increases thereafter up to 1990. For residual fuel oil, the forecast shows an increase of 19% for 1981, and again in 1982, and 11.5% annual increases thereafter up to 1990. For the sake of conservatism, this study has assumed that the cost of electric power will increase at the compounded rate of 11% annually. The revenue calculations were based on rates effective in the fall of 1980, and are as follows:

Capacity = \$69/yr//kW

Energy = \$0.060/kWh - on peak

\$0.050/kWh - off peak

\$0.054/kWh - average price for all kWh

2. Value of Water

The value of water has been added to those projects that will increase the firm delivery of water to the City. The value was estimated as being equivalent to the lowest cost from a source other than from the Hetch Hetchy system. The alternate source was assumed to be from the State of California Water Project as a participant of a larger development at a cost of about \$245 per acre-foot delivered in the California Aqueduct. An additional \$30 per acre-foot was estimated for pumping, treatment, pipeline and wheeling costs to yield a total value of water at \$275 per acre-foot of firm deliverable water.

SECTION 7

POTENTIAL PROJECTS

SECTION 7

POTENTIAL PROJECTS

7.1 PROJECT NO. 1 KIRKWOOD POWERHOUSE ADDITION

1. General:

Since 1967, the existing Robert C. Kirkwood Powerhouse has been operated to its power generating capacity (average load factor = 100%) by using the water supply discharge from the Hetch Hetchy Reservoir. The high runoff season of the Hetch Hetchy reservoir normally occurs in June, July, and August. The 38 year (1940-1979) spill record of the O'Shaughnessy Dam Spillway shows that the average amount of water spilled has been 180,500 acre-feet annually, which is equal to about 1000 cfs over the spill period. This project would use a portion of the water presently spilled for power generation at Kirkwood Powerhouse by substituting a power generating unit for the existing by-pass valve. Records show that the present power tunnel and penstock are capable of passing a quantity of water (1100 cfs) capable of operating the two present units at 115% of their rated capacity plus one additional unit of about 21 MW capacity. However, if one additional unit of 33.75 MW, which is identical to the two existing units, is installed, all three units could operate near their rated capacity, and would provide operational flexibility.

2. Project Features:

   a. Project Location: This new addition would be located at the existing by-pass valve area which is adjacent to the powerhouse. The general layout of the modification is shown on Plate 2.

b. Penstock: The existing bypass conduit would be modified and connected to the new turbine. By closing the existing shut-off valve, construction of the powerhouse addition would not interrupt the present powerhouse operation. The modified by-pass conduit would carry a design flow of 370 cfs under a head of 1245 feet to the new turbine.

c. Capacity and Energy Potential: Under a net operating head of 1245 feet with a three-month average plant flow of 1100 cfs, the additional energy potential of the Kirkwood Powerhouse would be 45.3 million kWh. During Sundays when one unit is shut down for maintenance, but flows to the City must be maintained, an additional 4.2 million kWh of power would be generated with the water presently passed through the bypass valve.

d. Powerhouse Modification: The third generating unit would be identical to the existing two 33.75 MW vertical shaft impulse turbines and generators. This will allow operating flexibility. The powerhouse modification would enlarge the existing powerhouse, and some modification of the bypass tunnel entrance would be required.

The major advantage of this project is that power generation from the existing two units can be maintained during installation of the third unit. The major disadvantage is that in the event of a complete outage of the Kirkwood Powerhouse, the City's water supply must be released at O'Shaughnessy Dam, flow down the Tuolumne River, and diverted into Mountain Tunnel at Early Intake due to the loss of the bypass valve.

3. Costs, Benefits, and Economic Feasibility:

The total investment cost of the Kirkwood Powerhouse Addition includes the costs of powerhouse enlargement, new power generating equipment and auxiliary equipment. The estimated total investment cost would be $26.55 million financed by a bond issue of $30 million.

The estimated average annual power benefit would be $5.0 million in 1986, the projected year of first commercial operation. The benefit-cost ratio is 1.51. In evaluating the project benefits, no benefit was assigned for firm capacity, since this project would only use the water that would otherwise be seasonally spilled at O'Shaughnessy Dam.

4. Compatibility with Hetch Hetchy System:

The present Kirkwood Powerhouse generation schedule requires one unit to be out of service every second Sunday. Some water that would normally pass through the unit in maintenance is presently passed through the bypass valve. With the addition of a new unit in place of the bypass valve, two units would be in operation on Sundays. The water presently "wasted" through the bypass valve would be used for power generation instead. Since the water passing through the turbines and bypass valve are both conveyed into the water supply for the City, this Kirkwood addition would be completely compatible with the present Hetch Hetchy system. This project is completely independent. No other project need be constructed in order to fulfill its beneficial use. The project is also independent of, and will have no impact on, the previously proposed Clavey-Wards Ferry Project. The project may be combined with the raising of O'Shaughnessy Dam, as described in Project No. 2.

Project Data Sheet

Project No. 1 Project Name: Kirkwood Powerhouse Addition

General and Technical Data

Location: Kirkwood Powerhouse

Dam, Type: Concrete Gravity Arch (Existing)

Normal Max. W.S. Elevation: 3806 Feet

Avg. Operating Head: 1245 Feet

Estimated Design Flow (For new additional unit): 370 c.f.s.

Installed Capacity: 33.75 MW

Number of Units: One additional

Type of Turbine: Vertical Shaft Impulse Turbine

Load Factor: 18% for the new unit

Annual Energy Production: 49,504,000 kWh

Spillway, Type: Side - Channel (existing)

Power Conduit, Type: Tunnel, existing

Penstock, Type: Steel, existing

Total Bond Issue: $30,000,000

Project Data Sheet

Project No. 1 Project Name: Kirkwood Powerhouse Addition

Bid Date: Mid 1983

On Line: Mid 1986

Annual Cost:

(1)	Amortization and Interest* Payment (9% interest - 40 years)	$ 2,529.000
(2)	Operation and Maintenance Costs ($\$5.19/kW \times 1.08^n$)	350,000
(3)	Interim Replacements Costs (1.4% of power plant cost)	270,000
(4)	Administrative and General (39% of (2))	140,000
(5)	Insurance (0.1% of Construction Cost)	20,000
(6)	Property Taxes	-
	TOTAL	$ 3,309,000

Annual Benefit

(1)	Capacity ($\$69 \times 1.11^n$)	-
(2)	Energy (0.054×1.11^n)	$ 5,000,000
	TOTAL	$ 5,000,000

Benefit-Cost Ratio (B/C) 1.51

First year's net income $ 1,691,000

Remarks

Output during spill season for 1100 cfs = 98.5 MW

Capability of present units @ 115% rated = 78.0 MW

Added Capacity = 20.5 MW

Generation = 20.5 x 92 days x 24 = 45,264,000 kWH

plus 20 Sundays x 26.5 MW** x 8 = 4,240,000

Added Generation = 49,504,000 kWH

*Interest on bond issue less the credit for interest on the reserve fund

**Based on 730 cfs plant flow minus 115% x 33.75 MW

Project Cost Estimate Summary

Bid Date: Mid 1983
On Line: Mid 1986

Project No. 1 Project Name: Kirkwood Powerhouse Addition

Major Cost Items	Cost (10^6 x $)(1986)
Power Plants	17.31
Access Roads	
Others	
Total Direct Cost	17.31
15% Contingency	2.60
(1) Total Construction Cost	19.91
(2) Engineering and Admin. Costs (17.5%)	3.48
(3) Total Project Cost	23.39
(4) Interest During Construction, 3 yrs. (3) x IDC (0.135)	3.16
(5) Total Investment Cost ((3) + (4))	26.55
(6) Reserve Fund *	2.79
(7) Financing Expenses**	.30
(8) Working Capital***	.06
(9) Bond Issue	29.70
Say	$ 30,000,000

* Reserve Fund based on one year's debt service assuming 9%-40-year level
** Based on 1% of total financing
*** Based on 0.2% of total financing

7.2 PROJECT NO. 2 - RAISING O'SHAUGHNESSY DAM WITH KIRKWOOD POWERHOUSE ADDITION

1. General:

It is recognized that the restricted size of the Hetch Hetchy Reservoir is the weak link in the Hetch Hetchy water supply system. An average of 180,500 acre-feet of water is spilled in a normal year which, if stored, could provide a more reliable water supply for the City. This project would raise O'Shaughnessy Dam by some 50 feet to increase the storage capacity of Hetch Hetchy Reservoir by 104,000 acre-feet. The height of 50 feet was selected for study since any substantial increase over that height could require an extensive saddle dam at the left abutment. It was further considered that a 50-foot increase in height would have a minimal effect on the environment, since it would affect only the dam and spillway structures. This project was combined with Project No. 1 to determine if a combined increase in height of O'Shaughnessy Dam, together with an additional unit at Kirkwood Powerhouse, would have a benefit-cost ratio greater than 1.0; indicating that the City could increase the reliability of the water supply at no cost to the taxpayer. Plate 2 shows the studied cross sections of the O'Shaughnessy Dam and Spillway modifications.

2. Project Features:

   a. Modification of dam: The O'Shaughnessy Dam would be raised 50 feet to El. 3862 by adding concrete to the top and downstream face, as shown on Plate 2. The O'Shaughnessy Spillway would also be raised 50 feet, with a modification to the existing channel. Initial studies show that the raised dam would be stable as a gravity structure. The next phase should determine the optimum

method of raising the dam; such as, using post-tensioned tendons, combined arch-gravity action, or a combination of both methods.

b. Powerhouse and Penstock: A new power generating unit would be added to the Kirkwood Powerhouse, as described in Project No. 1.

c. Capacity and Energy Potential: Raising O'Shaughnessy Dam increases the gross head to 1498 feet. The study shows that the year-round flow for the Kirkwood Powerhouse and its new addition would be increased to 874 cfs, and the average operating head would be increased to 1263 feet. All other new operating characteristics would be the same as Project No. 1. The resulting year round capacity and energy for the new unit would be:

Installed capacity	33.75 MW
Additional Firm Capacity	14.1 MW
Annual Energy Production	153.0 million kWh

3. Costs, Benefits, and Economic Feasibility:

The total investment cost of this project includes the costs of raising the dam, access roads and the Kirkwood Powerhouse additions. The estimated total investment cost would be $127.15 million financed by a bond issue of $142.5 million.

The estimated average annual power benefit would be $19.81 million in 1986, the projected first year of commercial operation. The benefit-cost ratio is 1.54. In evaluating the power benefits, a capacity value was assigned for the increased firm capacity, due to the available increase in regulated flow. The value of the additional stored water after 1990, when the projected water delivery of the Hetch Hetchy system will exceed 330 million gallons per day, is estimated to be $12.1 million. In projecting the benefits to 1990, the benefit-cost ratio for water and power is 2.48.

4. Geotechnical Opinion:

The existing dam is located in a glacial-cut canyon in an area of sound massive granite with essentially no weathered surficial material, and very few adverse rock joints. The reservoir perimeter is entirely sound granite with only local accumulations of rock talus.

The foundation area for the slab of new concrete proposed for the downstream face of the existing dam consists of fresh sound granite. Foundation preparation for the new concrete would require controlled blasting to shape the rock in locations where the abutments diverge in a downstream direction. The original foundation excavation for the existing dam showed that the valley has a "wineglass" profile at the dam location. This profile is represented by a deep narrow boulder-filled gorge in the bedrock below the elevation of the pre-dam streambed. Foundation excavation for the proposed additional concrete on the downstream dam toe would probably not have to extend into this deep inner gorge, but could arch across it, if design analysis shows this to be appropriate. The foundation rock exposed at the face of the existing dam is particularly sound and would be capable of supporting the additional arch loads.

The rock exposed adjacent to the crest of the existing dam's left abutment contains surficial jointing and minor weathering, but appears to be adequate to allow the 50-foot raising of the existing spillway structure. Both the rock conditions and the existing topography appear to be favorable for a new rock-cut spillway exit channel, located 50 feet higher on the left abutment. This channel would have to be excavated with controlled blasting techniques.

The abutment conditions at O'Shaughnessy Dam appear to be geologically suitable for the addition of the downstream concrete and for the spillway modifications required for raising the dam crest 50 feet.

5. Environmental Checklist:

Category	Insignificant or Minor Impacts	Mitigable Impacts	Potentially Significant Impacts
Land Use			
Compatibility	X		
Special Use			
Designations			X
Vegetation		X	
Wildlife		X	
Hydrology		X	
Water Quality		X	
Noise		X	
Socioeconomics	X		
Visual Resources			X

6. Compatibility with Hetch Hetchy System:

Raising O'Shaughnessy Dam, and the addition of another unit at Kirkwood Powerhouse could be two independent, but related, projects. The combined projects would not only increase hydroelectric power production, but would contribute measurably in supplying firm water yield to the City and County of San Francisco. This project may be constructed independently with only minor impacts on existing facilities. The reduction of normal spring spills should have no effect on the fish flows in the Tuolumne River. There would be no impact on the previously proposed Clavey-Wards Ferry Project during normal years; however, there may be a very minor impact during periods of drought, because additional water could be stored at Hetch Hetchy.

Project Data Sheet

Project No. 2 Project Name: Raising O'Shaughessy Dam with Kirkwood Powerhouse Addition

General and Technical Data

Location: At existing O'Shaughessy Dam and Kirkwood Powerhouse

Dam, Type: Concrete Gravity - Arch (Existing)

Height: 430 Feet

Approx. Crest Length: 910 Feet

Concrete Gravity - Arch (Raised)

Height: 480 Feet

Approx. Crest Length: 1000 Feet

Normal Max. W.S. Elevation: 3856 Feet

Avg. Operating Head: 1263 Feet

Estimated Design Flow (For 3 unit): 874 cfs

Installed Capacity: 33.75 MW

Additional Firm Capacity: 14.1 MW

Number of Units: One additional

Type of Turbine: Vertical Shaft Impulse Turbine

Load Factor: 60% for the new unit

Annual Energy Production: 177,222,000 kWh

Spillway, Type: Side - Channel

Power Conduit, Type: Tunnel, existing

Penstock, Type: Steel, existing

Total Bond Issue: $142,500,000

Project Data Sheet

Project No. 2 Project Name: Raising O'Shaughnessy Dam with Kirkwood Powerhouse Addition
Bid Date: Mid 1983
On Line: Mid 1986

Annual Cost:

(1) Amortization and Interest Payment (9% interest - 40 years)	$ 12,015,000
(2) Operation and Maintenance Costs ($5.19/kW x 1.08^n)	350,000
(3) Interim Replacements Costs (1.4% of power plant cost)	270,000
(4) Administrative and General (39% of (2))	140,000
(5) Insurance (0.1% of Construction Cost)	97,000
(6) Property Taxes	-
TOTAL	$ 12,872,000
Annual Benefit, Power Only	
(1) Capacity ($69 x 1.11^n)	$ 4,360,000
(2) Energy (0.054 x 1.11^n)	$ 15,454,000
SUBTOTAL	$ 19,814,000
Benefit-Cost Ratio (B/C) for Power only	1.54
First year's net income from power only	$ 6,942,000
(3) Value of Additional Stored Water* ($275.00 x 44,000 AF)	$ 12,100,000
Total Annual Benefit, Power and Water	$ 31,914,000
Benefit-Cost Ratio (B/C) Power and Water	2.48
First year's net income from power plus value of water	$ 19,042,000

* After about 1990 when it is projected that Hetch Hetchy must supply over 330 MGD

Remarks

Output at average flow (874 cfs)	= 79.6 MW
Output at present average flow (730) cfs	= 65.5 MW
Added Capacity	= 14.1 MW
Generation due to additional storage	= 123,052,000 kWH
plus, in lieu of spilled water:	
20,800 kW x 60 days x 24**	= 29,952,000
Added Generation	= 153,004,000 kWH

** From computer analysis

Project Cost Estimate Summary

Bid Date: Mid 1983

On Line: Mid 1986

Project No. 2 Project Name: Raising O'Shaughnessy Dam with Kirkwood Powerhouse Addition

Major Cost Items	Cost (10^6 x $)(1986)
Land and Land rights	
Reservoir	
Dam (a) Concrete	57.74
Spillway	6.78
Power Plants	17.31
Access Roads, Contractor's Operations	1.44
Others: Public Area, Quarry Rights	1.44
Total Direct Cost	84.71
15% Contingency	12.71
(1) Total Construction Cost	97.42
(2) Engineering and Admin. Costs (15%)	14.61
(3) Total Project Cost	112.03
(4) Interest During Construction, 3 yrs. (3) x 1DC (0.135)	15.12
(5) Total Investment Cost ((3) + (4))	127.15
(6) Reserve Fund *	13.25
(7) Financing Expenses**	1.42
(8) Working Capital***	.28
(9) Bond Issue	142.10
Say	$142,500,000

* Reserve Fund based on one year's debt service assuming 9%-40-year level
** Based on 1% of total financing
*** Based on 0.2% of total financing

7.3 PROJECT NO. 3 EARLY INTAKE POWERHOUSE REPLACEMENT

1. General:

The original Early Intake Powerhouse was the first hydroelectric power generation facility on the Hetch Hetchy system. Water to this powerhouse was supplied from Lake Eleanor and the natural flow of the Cherry River through an aqueduct. The original powerhouse, which had a plant capacity of 3.0 MW, was demolished after the construction of the 135 MW Holm Powerhouse. The penstock is still in place and in fairly good condition. This Early Intake Powerhouse Replacement project would reconstruct the original powerhouse except it would have a single 2.25 MW unit, instead of three 1 MW units. Although the Lower Cherry Aqueduct was originally designed to carry 200 cfs, the capacity has decreased to 155 cfs; therefore, this project has been evaluated using the lesser flow. If it is found, at the time the decision is made to proceed with this project, that the cost of improving the aqueduct to carry a flow of 200 cfs, is nominal, then the plant capacity can be increased to 3.0 MW. Due to upstream developments and restrictions on releases from Lake Eleanor, this powerhouse could be used only during the period when Lake Eleanor spills, or when releases from Lake Eleanor and Lake Lloyd may be regulated during a drought period.

2. Project Features:

   a. Location of the Project: The powerhouse would be located on the right bank of the Tuolumne River at the original powerhouse site. The discharge from the powerhouse would normally enter the Tuolumne River. However, a valving system would be provided so that during periods of drought, the water could enter the Mountain Tunnel through a siphon, as was previously done with the original Early Intake Powerhouse.

Capacity and Energy Potential: Under a net operating head of 200 feet and a design flow of 155 cfs, the capacity and energy potential of the project, at an average load factor of 25%, would be:

Installed Capacity = 2.25 MW

Annual Energy Production = 4.93 million kWh

3. Costs, Benefits, and Economic Feasibility:

The total investment cost of the Early Intake Powerhouse replacement includes the costs of downstream siphon, powerhouse, and power generation equipment. The estimated total investment cost would be $4.51 million financed by a $5.1 million bond issue.

The estimated average annual power benefit would be $463,000 in 1984, the projected year of first commercial operation. The benefit-cost ratio is 0.92.

4. Compatibility with Hetch Hetchy System:

The Early Intake Powerhouse Replacement would be an independent improvement; it would not preclude another project. This project would not only add energy production (4.93 million kWh per year) to the Hetch Hetchy Power System, but also provide the Mountain Tunnel with additional water. It is completely compatible with the present Hetch Hetchy system. This project would not be feasible if the Eleanor-Cherry Tunnel Pumping Project, being studied by the City, is constructed, since the water that would have been used at this project would be pumped into Lake Lloyd. This project would not impact the previously proposed Clavey-Wards Ferry Project.

Project Data Sheet

Project No. 3 Project Name: Early Intake Powerhouse Replacement

Location: At the original Early Intake Site

Dam, Type: None

Normal Max. W.S. Elevation: Est. Top of Penstock 2560 feet

Avg. Operating Head: 200

Estimated Design Flow: 155 cfs

Installed Capacity: 2.25 MW

Number of Units: 1

Type of Turbine: Francis Turbine

Load Factor: 25%

Annual Energy Productions: 4,930,000 kWh

Power Conduit, Type: Open channel (existing)

Penstock, Type: Steel (existing)

Avg. Inside Diameter: 3 Feet

Total Bond Issue: $5,100,000

Project Data Sheet

Project No. 3 Project Name: Early Intake Powerhouse Replacement
Bid Date: Mid 1982
On Line: Mid 1984

Annual Cost:

(1)	Amortization and Interest* Payment (9% interest - 40 years)	$ 430,000
(2)	Operation and Maintenance Costs ($5.19/kW x 1.08^n)	20,000
(3)	Interim Replacements Costs (1.4% of power plant cost)	40,000
(4)	Administrative and General (39% of (2))	8,000
(5)	Insurance (0.1% of Construction Cost)	4,000
(6)	Property Tax (approx. 6% of net income)	
	TOTAL	$ 502,000

Annual Benefit

(1)	Capacity ($69 x 1.11^n @ 25%))	$ 59,000
(2)	Energy (0.054 x 1.11^n)	$ 404,000
	TOTAL	$ 463,000

Benefit-Cost Ratio (B/C) — 0.92

*Interest on bond issue less credit for interest on the reserve fund.

Preliminary Cost Estimate Summary

Bid Date: Mid 1982
On Line: Mid 1983

Project No. 3   Project Name: Early Intake Powerhouse Replacement

Major Cost Items:		Cost (10^6 x $)(1984)
Penstock		0.14
Power Plant		2.81
Access Roads		
Others	siphon discharge	0.11
Total Direct Cost		3.06
15% Contingency		.46
(1) Total Construction Cost		3.52
(2) Engineering and Overhead Costs (17.5%)		.62
(3) Total Project Cost ((1) + (2))		4.14
(4) Interest During Construction, 2 yrs (3) x 1DC (0.09)		.37
(5) Total Investment Cost ((3) + (4))		4.51
(6) Reserve Fund *		.48
(7) Financing Expenses**		.05
(8) Working Capital***		.01
(9) Bond Issue		5.05
	Say	$ 5,100,000

* Reserve Fund based on one year's debt service assuming 9%-40-year level
** Based on 1% of total financing
*** Based on 0.2% of total financing

7.4 PROJECT NO. 4 SOUTH FORK TUOLUMNE

1. General:

The South Fork Tuolumne Project would be located at the confluence of the Middle and South Forks of the Tuolumne River. At the present time, this reach of the river has not been used for hydroelectric power development. A preliminary hydrological study was conducted by using 19 years (1951-1969) of flow records. It is estimated that an average flow of 169 cfs is available from a drainage area of 163 square miles. Based on the flow duration curve shown on Plate 3, a design flow of 240 cfs is estimated for a run-of-river power generation plant.

2. Project Features:

a. Location of the Project: A dam would be constructed at the confluence of the Middle Fork and South Fork Tuolumne River, about one mile west of the Oakland Recreation Camp. A tunnel and penstock would carry the power flow from the proposed dam to a powerhouse, which would be located at the South Fork Tuolumne River, about a mile downstream of the proposed dam. A general layout of the project is shown on Plate 3.

b. Dam: The proposed dam would be an uncontrolled overflow concrete gravity dam. The dam would be about 220 feet high, with the top of dam at elevation 2620 feet. The crest length would be about 420 feet.

c. Power Tunnel and Penstock: An unlined 8 foot horseshoe or circular shaped tunnel would be constructed for about 4500 feet, and would daylight at elevation 2400 feet. From this point, an 1100-foot long penstock would be constructed above ground to the powerhouse.

This arrangement would create a gross head of 920 feet for power generation.

d. Powerhouse: The Powerhouse would be located on the right bank of the South Fork Tuolumne River. It would be a typical reinforced concrete powerhouse housing one power generating unit driven by a vertical Francis turbine.

Capacity and Energy Potentials: Under a net operating head of 882 feet and a design flow of 240 cfs, the capacity and energy potential of the project, at an average 45% load factor, would be:

Installed Capacity	=	15.2 MW
Annual Energy Production	=	59.9 million kWh

3. Costs, Benefits, and Economic Feasibility:

The total investment cost of the South Fork Tuolumne Project includes the costs of the dam, power intake and outlet, power tunnel, penstock, powerhouse, and power generating equipment. The estimated total investment cost would be $81.8 million financed by a bond issue of $91.5 million. Since the project is located within the boundaries of the Stanislaus National Forest, no land acquisition costs were assigned.

The estimated average annual power benefit would be $9.88 million in 1988, the projected year of first commercial operation. The benefit-cost ratio is 1.18.

4. Geotechnical Opinion:

Both the damsite and the tunnel would be located in granitic rock of the Sierran batholith. This location is close to the margin of the granite batholith, where it is in intrusion contact with overlying meta-sediments to the south, west, and north. The fact that this granitic rock is closer to the

batholith margins tends to make it of lesser engineering quality, and more susceptible to weathering than the massive granite exposures in the higher Sierra Nevada areas. Weathering would extend to various depths on the dam abutments, but this should not be excessive enough to preclude building a concrete dam at this location.

The area topography indicates that this stretch of the South Fork is in an active downcutting erosion stage, so it is not anticipated that a deep alluvial-filled bedrock gorge would be encountered. Downstream, where the South Fork joins the Tuolumne river, the South Fork is depositing river gravels. These gravels would provide a potential source of concrete aggregate for the dam.

Tunneling conditions through the granitic rock can be expected to be relatively good. With conventional tunneling methods, overbreak should be light to moderate. Heavy ground water flows would not be expected. Most of the tunnel could probably be unlined, and areas of local instability could be reinforced with rock bolts and shotcrete. To mitigate post-construction visual impacts, tunnel muck could be disposed of in the reservoir area; However, this would require driving the tunnel in the down-grade direction.

At the present level of the geologic investigations, there are no apparent geologic conditions which would have a severe adverse impact on the design and construction of the South Fork Tuolumne scheme.

5. Environmental Checklist:

Category	Insignificant or Minor Impacts	Mitigable Impacts	Potentially Significant Impacts
Land Use			
Compatibility			X
Special Use			
Designations			X
Vegetation		X	
Wildlife		X	
Hydrology			X
Water Quality		X	
Noise		X	
Socioeconomics	X		
Visual Resources			X

6. Compatibility with Hetch Hetchy System:

The South Fork Tuolumne Project would be compatible with the Hetch Hetchy system because the generating station would be located adjacent to lands normally associated with the Hetch Hetchy system. The power generated could be transmitted over the existing Hetch Hetchy transmission lines. This project will be precluded if Project No. 6, Harden Flat Dam and Power Plant is to be constructed.

This project would have no impact on the previously proposed Clavey-Wards Ferry Project.

Project Data Sheet

Project No. 4 Project Name: South Fork Tuolumne

Power Plant Classification: Run-of-River

Location: Junction of Middle Fork and South Fork

Dam, Type: Concrete

Height: 220 Feet (1 week's storage)

Approx. Crest Length: 420 Feet

Normal Max. W.S. Elevation: 2620 Feet

Avg. Operating Head: 882 Feet

Estimated Design Flow: 240 cfs

Installed Capacity: 15.2 MW

Number of Units: One

Type of Turbine: Francis

Load Factor: 45%

Annual Energy Production: 59,920,000 kWh

Spillway, Type: Uncontrolled Ogee

Power Conduit, Type: Horseshoe, Unlined 4,500 Feet

Inside Diameter: 8 Feet

Penstock, Type: Steel 1100 Feet

Avg. Inside Diameter: 4 Feet

Total Bond Issue: $91,500,000

Project Data Sheet

Project No. 4 Project Name: South Fork Tuolumne
Bid Date: Mid 1985
On Line: Mid 1988

Annual Cost

(1)	Amortization and Interest* Payment (9% interest - 40 years)	$ 7,714,000
(2)	Operation and Maintenance Costs ($5.19/kW x 1.08^n)	180,000
(3)	Interim Replacements Costs (1.4% of power plant cost)	195,000
(4)	Administrative and General (39% of (2))	70,000
(5)	Insurance (0.1% of Construction Cost)	63,000
(6)	Property Tax (approx. 6% net income)	92,000
	TOTAL	$ 8,314,000

Annual Benefit

(1)	Capacity ($69 x 1.11^n)	$ 2,417,000
(2)	Energy (0.054 x 1.11^n)	$ 7,457,000
	TOTAL	$ 9,874,000

Benefit-Cost Ratio (B/C)	1.18
First year's net income	$ 1,560,000

*Interest on bond issue less credit for interest on the reserve fund.

Preliminary Cost Estimate Summary

Bid Date: Mid 1985
On Line: Mid 1988

Project No. 4 Project Name: South Fork Tuolumne

Major Cost Items:	Cost (10^6 x $)(1988)
Land and Land rights	
Reservoir	
Dam: a) Earthfill (or Rockfill)	
b) Concrete	23.79
Intake	1.70
Diversion Tunnel	1.36
Power Tunnel	9.67
Penstock	2.55
Power Plant	13.90
Access Roads	.85
Others, Transmission Line	.68
Total Direct Cost	54.5
15% Contingency	8.17
(1) Total Construction Cost	62.67
(2) Engineering and Admin. Costs (15.0%)	9.40
(3) Total Project Cost	72.07
(4) Interest During Construction, 3 yrs (3) x IDC (0.135)	9.73
(5) Total Investment Cost ((3) + (4))	81.80
(6) Reserve Fund *	8.51
(7) Financing Expenses**	.92
(8) Working Capital***	.18
(9) Bond Issue	91.41
Say	$ 91,500,000

* Reserve Fund based on one year's debt service assuming 9%-40-year level
** Based on 1% of total financing
*** Based on 0.2% of total financing

7.5 PROJECT NO. 5 TAWONGA CAMP PROJECT

1. General:

The Tawonga Camp Project would be located near Camp Tawonga (formerly Columbia Camp), a privately owned summer campsite. Preliminary hydrologic investigation was conducted by using 19 years (1951-1969) of flow records. The average flow at the project site is 67 cfs from a drainage area of 65.5 square miles. The flow duration curve, Plate 4, shows that a design flow of 88 cfs is available for a run-of-river power plant.

2. Project Features:

   a. Location of the Project: A dam would be constructed on the Middle Fork Tuolumne River about 1/4-mile southeast of Camp Tawonga. It would be about 200' downstream of the existing pumping station, which is presently being used to supply domestic water for Camp Tawonga. The general layout of the project is shown on Plate 4.

   b. Dam: The proposed dam would be an uncontrolled overflow concrete gravity dam about 77 ft. high. The top of the dam would be at elevation 3762', with a crest length of 590'.

   c. Penstock: A steel penstock would be constructed along the left bank of the river. The penstock would be about 8,000 ft. long, with a diameter of 42 inches. It would be designed to carry 88 cfs of water from the reservoir to the powerhouse. With this arrangement, it would create a gross head of 647' for power generation. No minimum fish flow releases were calculated for this project, since this reach of the river presently has

no measurable flow during late fall, during which time the plant would be shut down.

d. Powerhouse: The powerhouse would be located about 7,500 ft. downstream of the dam, on the left bank of the Middle Fork Tuolumne River. It would be a typical reinforced concrete powerhouse containing one power generating unit with a Francis turbine. Due to the length of penstock, a long governor time would be required. However, for this run-of-river plant, a long governor time should be acceptable.

e. Capacity and Energy Potential. Under a net operating head of 614 feet and a design flow of 88 cfs, the capacity and energy potentials of the project, at an average load factor of 44%, would be:

Installed Capacity = 4 MW

Annual Energy Productions = 15.0 million kWh

3. Costs, Benefits, and Economic Feasibility:

The total investment cost of the Camp Tawonga Project includes the costs of dam, reservoir preparation and clearing, power intake, penstock, powerhouse and power generation equipment, switching station and a transmission line to the City's 22 kV line. The estimated total investment cost would be $24.38 million financed by a bond issue of $27.5 million. In evaluating the property acquisition costs, a value of $1 million was applied.

The estimated average annual power benefit would be $2.114 million. The benefit-cost ratio is 0.86.

4. Geotechnical Opinion:

Tawonga Camp damsite is located within a large region of granitic rock that forms the higher elevations of the Sierra Nevada. The site is in rolling terrain, just upstream from where both the gradient of the Middle Fork and the topography become much steeper. Bold, slightly spheroidally weathered outcrops of granite are exposed on both abutments of the damsite; the stream channel deposits consist of a combination of sand and very large boulders. Weathering along steep joints in the granite probably extends to depths of 20 feet or more, as is typical in rolling granitic terrain.

Excavating the foundation for a low concrete-gravity overflow dam would entail removal of boulders and outcrops surrounded by weathering. Controlled blasting would be required for foundation shaping. Curtain grouting and possibly some pattern grouting to fill joints will also be needed. Grout requirements should be moderate.

Tawonga Camp damsite appears to be geologically suitable for a concrete gravity overflow dam of the size being considered.

5. Environmental Checklist:

Category	Insignificant or Minor Impacts	Mitigable Impacts	Potentially Significant Impacts
Land Use			
Compatibility			X
Special Use			
Designations	X		
Vegetation			X
Wildlife		X	
Hydrology		X	
Water Quality		X	

Category	Insignificant or Minor Impacts	Mitigable Impacts	Potentially Significant Impacts
Noise		X	
Socioeconomics			X
Visual Resources			X

6. Compatibility with Hetch Hetchy Systems

The Tawonga Camp Project would use the natural flow of an undeveloped reach of the Middle Fork Tuolumne River for power generation. The project would not only add energy production (15 million kWh per year) to the Hetch Hetchy Power System, but the low overflow dam and reservoir would provide adequate water supply to the Tawonga Camp during the dry summer months. The project is completely compatible with the present Hetch Hetchy system. This project would be precluded if Project No. 6, Harden Flat Project, is constructed, since a major portion of the water would be diverted into the South Fork Tuolumne River under the Harden Flat Project. This project would have no impact on the previously proposed Clavey-Wards Ferry Project.

Project Data Sheet

Project No. 5 Project Name: Tawonga Camp Project

Location: Middle Fork Tuolumne River near Tawonga Camp

Dam, Type: Concrete

Height: 77 Feet

Approx. Crest Length: 590 Feet

Normal Max. W.S. Elevation: 3762

Avg. Operating Head: 614 Feet

Estimated Design Flow: 88 cfs

Installed Capacity: 4 MW

Number of Units: One

Type of Turbine: Francis

Load Factor: 44%

Annual Energy Productions: 15,000,000 kWH

Spillway, Type: Uncontrolled Ogee

Penstock, Type: Steel

Avg. Diameter: 42 Inches

Total Bond Issue: $27,500,000

Project Data Sheet

Project No. 5 Project Name: Tawonga Camp Project
Bid Date: Mid 1985
On Line: Mid 1988

Annual Cost

(1)	Amortization and Interest* Payment (9% interest - 40 years)	$ 2,318,000
(2)	Operation and Maintenance Costs ($5.19/kW x 1.08^n)	48,000
(3)	Interim Replacements Costs (1.4% of power plant cost)	60,000
(4)	Administrative and General (39% of (2))	19,000
(5)	Insurance (0.1% of Construction Cost)	18,000
(6)	Taxes (approx. 6% net income)	--
	TOTAL	$ 2,463,000

Annual Benefit

(1)	Capacity @ $40% ($69 x 1.11^n)	$ 254,000
(2)	Energy (0.054 x 1.11^n)	$ 1,860,000
	TOTAL	$ 2,114,000

Benefit-Cost Ratio (B/C) 0.86

*Interest on bond issue less credit for interest on the reserve fund.

Preliminary Cost Estimate Summary

Bid Date: Mid 1985
On Line: Mid 1988

Project No. 5 Project Name: Tawonga Camp Project

Major Cost Items:	Cost (10^6 x \$)(1988)
Land and Land rights	1.70
Reservoir	.22
Dam: a) Earthfill (or Rockfill)	
b) Concrete	3.50
Spillway	
Intake and Outlet	.78
Diversion Tunnel	
Power Tunnel	
Penstock	4.69
Power Plant	4.25
Access Roads	.08
Others Transformer, Swyd and Trans. Line	.68
Total Direct Cost	15.90
15% Contingency	2.38
(1) Total Construction Cost	18.28
(2) Engineering and Admin. Costs (17.5%)	3.20
(3) Total Project Cost	21.48
(4) Interest During Construction, (3 yrs) 3 x 1DC (0.12)	2.90
(5) Total Investment Cost	24.38
(6) Reserve Fund*	2.56
(7) Financing Expense**	.28
(8) Working Capital***	.10
(9) Bond Issue	27.32
Say	\$27,500,000

* Reserve Fund based on one year's debt service assuming 9%-40-year level
** Based on 1% of total financing
*** Based on 0.2% of total financing

7.6 PROJECT NO. 6 HARDEN FLAT DAM AND POWER PLANT

1. Background:

The Harden Flat Dam and Power Plant was investigated by the Department of Water Resources, State of California, Bulletin No. 96, in 1965. The objective of the investigation was to formulate a plan of water development for domestic water supply, irrigation, recreation, conservation, and hydroelectric power in Southern Tuolumne County.

In 1968 the Department of Water Resources published Bulletin No. 169 which stated that the project was economically unjustified. Technological advances in the production of thermal power had caused power values to decrease. With the increased hydroelectric plant construction costs, the Department of Water Resources decided to abandon the Harden Flat project and investigate development of other water resources in Southern Tuolumne County.

The value of energy has changed since 1969, as well as economic and environmental considerations as a whole, and hydroelectric power has again become a very desirable form of power generation.

2. General:

The Harden Flat Power Project would consist of the following features:

a. Mather Diversion and Ditch

b. Harden Flat Reservoir

c. Golden Rock Ditch

d. Lost Claim Forebay

e. Lost Claim Power Plant

The combination of these features would provide a power generation scheme with an annual energy production of 91 million kWh and an installed

capacity of 22 MW, based on a design flow of 165 cfs through 2,000 feet of gross head.

The project would divert 25,800 acre-feet, of the average annual flow of 40,300 acre-feet from the Mather diversion damsite on the Middle Fork Tuolumne River, to the South Fork. An additional 63,500 acre-feet would be available at the Harden Damsite from the South Fork of the Tuolumne River. The combined water supply of 89,300 acre-feet would be available at the Harden Flat Reservoir. Of the 89,300 acre-feet, it is calculated that 52,700 acre-feet could be diverted for power generation in a normal year.

3. Project Features:

   a. Mather Diversion and Ditch: The Mather Diversion Dam would be constructed on the Middle Fork Tuolumne River about 1-1/2 miles above the Middle Fork campground. The dam would consist of a concrete overpour section rising 20 feet from an elevation of 4,640 feet. From the dam, a canal would extend about 3-1/2 miles to its outlet on Ackerson Creek, 1.3 miles above the Ackerson Creek confluence with the South Fork of the Tuolumne River. The canal, (Mather Ditch), would have 16,000 feet of concrete-lined open canal and 2,500 feet of flume. The capacity would be 150 cubic feet per second.

   b. Harden Flat Dam and Reservoir: The proposed Harden Flat Dam would be constructed in a steep, narrow canyon in the South Fork Tuolumne River, approximately one-half mile west of the community of Harden Flat. It is proposed as an earth and rockfill structure, rising 235 feet from the streambed elevation of 3,435 feet. The crest would be 750 feet in length

and 30 feet wide. The dam would have upstream and downstream slopes of 2:1. The reservoir would inundate 430 acres of privately-owned meadow and forest land. Within the reservoir site, there are privately-owned improvements such as a summer lodge, cabins, service station, market, and horse stables.

c. Golden Rock Ditch: From Harden Flat, the Golden Rock Ditch would extend 8.7 miles west to Lost Claim Forebay. The alignment would follow an abandoned ditch. The ditch right-of-way is held by Southern Tuolumne County. The Golden Rock Ditch would consist of about 42,000 feet of concrete-lined open canal, 2,000 feet of flume, and 2,000 feet of inverted siphon. The capacity would be 165 cubic feet per second.

d. Lost Claim Forebay: Lost Claim Forebay would be formed by excavating a portion of the mountain top near Lost Claim Campground, adjacent to State Highway 120. The forebay would have a storage capacity of 50 acre-feet. This amount was selected to allow sufficient time for releases from Harden Flat Reservoir to reach the forebay, in case of a sudden power demand.

e. Lost Claim Power Plant: The power plant would be a conventional reinforced concrete power plant, housing one impulse turbine. The welded steel penstock to the power plant would be 3,360 feet long. Its diameter would vary from 54 inches at its inlet to 42 inches at its outlet. The power plant would operate under an estimated design head of 1,830 feet and have an installed capacity of 22.0 MW.

4. Costs, Benefits and Economic Feasibility:

The Department of Water Resources, Bulletin No. 96, 1965, has a cost estimate for the Harden Flat project based on 1961 costs. After updating the 1961 costs, the total investment cost is calculated to be $93.61 million. This cost does not include the Burch Meadow Conduit or the Burch Meadow Reservoir which were included in Bulletin No. 96, since these features of the project would not be part of a hydroelectric project. The project would be financed by a bond issue of $105 million.

The estimated average annual power benefit would be $16.41 million. The benefit-cost ratio is 1.65.

5. Geotechnical Opinion:

A well-presented geotechnical opinion of all of the Harden Flat Dam and Power Plant Project features can be found in the Department of Water Resources Bulletin No. 96, "Southern Tuolumne County Investigation", 1965. This information will not be repeated here.

6. Enviromental Checklist:

Category	Insignificant or Minor Impacts	Mitigable Impacts	Potentially Significant Impacts
Land Use			
Compatibility			X
Special Use			
Designations			X
Vegetation		X	
Wildlife		X	
Hydrology			X

Category	Insignificant or Minor Impacts	Mitigable Impacts	Potentially Significant Impacts
Water Quality		X	
Noise		X	
Socioeconomics			X
Visual Resources	X		

7. Compatibility with Hetch Hetchy System:

The Harden Flat Dam and Power Plant project is not dependent on any of the other projects; however, Project No. 4 South Fork Tuolumne, and Project No. 5, Tawonga Camp Site Project, would be precluded if this project is constructed. This project would not affect the previously proposed Clavey-Wards Ferry Project.

Project Data Sheet

Project No. 6   Project Name: Harden Flat Dam and Power Plant
Bid Date: Mid 1985
On Line: Mid 1989

General and Technical Data

Location: South Fork Tuolumne River

Dam, Type: Earth and Rockfill

Height: 235 Feet

Approx. Crest Length: 750 Feet

Normal Max. W.S. Elevation: 3655 Feet

Avg. Operating Head: 1830 Feet

Estimated Design Flow: 165 cfs

Installed Capacity: 22 MW

Number of Units: One

Type of Turbine: Impulse

Load Factor: 47%

Annual Energy Production: 90,700,000 kWh

Spillway, Type: Uncontrolled Ogee

Power Conduit, Type: Open Channel

Penstock, Type: Welded Steel

Avg. Inside Diameter: 4 Feet

Total Bond Issue: $105,000,000

Project Data Sheet

Project No. 6 Project Name: Harden Flat Dam and Power Plant
Bid Date: Mid 1985
On Line: Mid 1989

Annual Cost

(1) Amortization and Interest Payment (9% interest - 40 years)	$ 8,854,000
(2) Operation and Maintenance Costs ($5.19/kW x 1.08^n)	288,000
(3) Interim Replacements Costs (1.4% of power plant cost)	216,000
(4) Administrative and General (39% of (2))	112,000
(5) Insurance (0.1% of Construction Cost)	69,000
(6) Property Tax (approx. 6% net income)	390,000
TOTAL	$ 9,929,000

Annual Benefit

(1) Capacity ($69 x 1.11^n)	$ 3,883,000
(2) Energy (0.054 x 1.11^n)	$ 12,529,000
TOTAL	$ 16,412,000
Benefit-Cost Ratio (B/C)	1.65
First year's net income	$ 6,483,000

Preliminary Cost Estimate Summary

Bid Date: Mid 1985
On Line: Mid 1989

Project No. 6 Project Name: Harden Flat Dam and Power Plant

Major Cost Items:	Cost (10^6 x \$)(1989)
Land and Land rights	3.72
Reservoir	0.37
Dam: a) Earthfill (or Rockfill)	13.51
b) Concrete	0.96
Spillway	3.84
Intake and Outlet	2.73
Diversion Ditches	10.21
Power Tunnel	-
Penstock	5.70
Power Plant	15.40
Access Roads	1.77
Others Trans. Line, Swyd, Remote Control	1.77
Total Direct Cost	59.98
(Sum of all the Major Cost Items)	
15% Contingency	9.00
(1) Total Construction Cost	68.98
(2) Engineering and Admin. Costs (15%) (1) x 15 %)	10.35
(3) Total Project Cost	79.33
(4) Interest During Construction, (4 yrs) (3 x IDC (0.18)	14.28
(5) Total Investment Cost	\$ 93.61

(6)	Reserve Fund*		9.76
(7)	Financing Expenses**		1.05
(8)	Working Capital***		.21
(9)	Bond Issue		104.63
		Say	$105,000,000

* Reserve Fund based on one year's debt service assuming 9%-40-year level
** Based on 1% of total financing
*** Based on 0.2% of total financing

7.7 PROJECT NO. 7 LOWER MOCCASIN CREEK POWER PLANT

1. General:

The Lower Moccasin Creek Power Plant Project would convey the outflow from the Holm Powerhouse via a new tunnel to a powerhouse downstream of the Moccasin Dam. The discharges from this new powerhouse would flow into Don Pedro Reservoir. An 800-foot long bypass pipe line would be constructed to the edge of Moccasin Reservoir to allow augmenting the water supply during periods of drought. An alternate to the bypass pipeline would be a pumping station at the powerhouse to lift the water into Foothill Tunnel during periods of drought. The cost of either scheme would be about the same. The power plant would operate in tandem with the Holm Powerhouse units.

2. Project Features:

   a. Power Tunnel and Penstock: The water conveyance system would consist of the following features: Modification of the discharge water passage at Holm Powerhouse so that the outflow could be regulated to either discharge the water into the Cherry River as is presently being done, or to divert discharges into a pipeline. The pipeline would be located on the right bank of the Cherry River and would be about 1,500 feet long. The water would then be conveyed into a tunnel at a portal located near the spoil area used during the construction of Holm Powerhouse. The tunnel would have a total length of approximately 110,000 feet and would follow the alignment of the existing Mountain Tunnel after crossing the Tuolumne River.

This tunnel would be about 100 feet below the existing mountain tunnel; therefore, a connection could be made to allow water that could not be conveyed in Mountain Tunnel to spill into the new tunnel. The downstream tunnel portal would be about 7000 feet upstream of the powerhouse at elevation 2000 feet. The water would then be conveyed in a steel penstock. This penstock would bifurcate just upstream of the powerhouse into two penstocks to serve two units in the new powerhouse. This layout would result in a gross head of about 1330 feet and would carry a design flow of 830 cfs for power generation. The general layout is shown on Plate 5. Due to environmental concerns, the tunnel portal would be placed out-of-sight of Highway 120. The penstock would cross under the present Moccasin penstocks, and be buried at its lower reaches.

b. Powerhouse: The Lower Moccasin Creek Powerhouse would be a typical reinforced concrete powerhouse containing two power generating units driven by vertical impulse turbines. The powerhouse would be located downstream of the Moccasin Dam on the right bank of the Moccasin Creek just downstream of the existing sewage treatment plant. A synchronous pressure relief valve would be installed in the powerhouse to release high pressure water in case of power equipment malfunctions.

c. System Operation: During periods of high runoff in the Tuolumne River basin, there would be 1100 cfs available to both tunnels for a period of 92 days in an average year. Since the

capacity of the existing Mountain Tunnel is 730 cfs, 370 cfs could be transferred into the new tunnel. The most favorable operating scheme during the high runoff period would be to operate Holm Powerhouse with 460 cfs, thereby preserving 67,500 acre-feet in Lake Lloyd for future use. The load factor of Holm Powerhouse would be 56% during the 92-day runoff period and 73% during the remainder of the year.

d. Capacity and Energy Potential: Under a net operating head of 1100 feet with a design flow of 830 cfs, the capacity and energy potential of the project when operating at 100% load factor during the 92-day runoff period and 73% load factor during the remainder of year would be:

	During Runoff Period	Remainder of Year
Installed Capacity	65 MW	65 MW
Energy Production	145 million kWh	315 million kWh
Annual Energy Production	460 million kWh	

3. Costs, Benefits, and Economic Feasibility:

The total investment cost of the Lower Moccasin Creek Power Plant includes the costs of modifying Holm Powerhouse, tunnel, penstock, powerhouse, power generation equipment, by-pass valve house and pipelines. The estimated total investment cost would be $423.49 million financed by a bond issue of $473 million. No land acquisition cost was assigned to this project since the proposed tunnel is either in the Stanislaus National Forest or within the present right-of-way of Mountain Tunnel, and the powerhouse would be located on City property.

The estimated average annual power benefit would be $67.592 million. The benefit-cost ratio is 1.56 based on benefits from the sales of electrical power. There is an added benefit in that during periods of drought, this project would be able to augment the water supply to the City.

4. Geotechnical Opinion:

Geologic conditions at the power plant site and at tunnel portal locations were evaluated in the field on October 30, 1980.

About one-third of the tunnel, from just downstream of Holm power plant to just west of the South Fork of the Tuolumne River, would be in granitic rock with conditions very similar to those encountered in the Mountain Tunnel. The remaining two-thirds of the tunnel, from the South Fork to Moccasin, would be in late-Paleozoic-age metasedimentary rocks of the Calaveras Formation. These would primarily include phyllite and schist with some metachert, quartzite, and marble.

At the upstream end of the tunnel, part of a waste area containing material excavated during construction of Holm Power Plant would have to be excavated to establish the tunnel portal. Also, the portal area could accommodate very little additional waste material, so the first mile of the tunnel may have to be driven in an upstream direction, by first driving a temporary access incline having its portal at the Early Intake switchyard area. The latter area was the spoil area for tunnel muck from the upstream end of the Mountain tunnel, and it would be possible to accommodate the additional muck from the new tunnel at this location.

The new tunnel could be excavated by use of tunnelling machines, one starting at the upstream end (at Early Intake) and one at the downstream end near Moccasin. The downstream tunnel should be driven oversize so that it

could accommodate concrete lining where necessary for stability in certain portions of the metamorphic rock. However, the regional trend of the metamorphic foliation is steeply dipping and striking roughly perpendicular to the tunnel alignment, and this is favorable for tunnel stability.

Bedrock at the location of the proposed new power plant is at, or relatively near, the ground surface. It is part of the Jurassic-age Mariposa slate formation which strikes northwest and dips steeply northeast. The Mariposa slate is in fault contact with the Calaveras Formation along a strand of the Melones fault zone at this location. The new Moccasin Power Plant penstocks would cross this fault strand, as do the existing power plant penstocks.

There are apparently no seriously adverse geologic conditions, which would significantly impact the suitability of the proposed new facilities, along the proposed tunnel alignment.

5. Environmental Checklist:

Category	Insignificant or Minor Impacts	Mitigable Impacts	Potentially Significant Impacts
Land Use			
Compatibility	X		
Special Use			
Designations	X		
Vegetation		X	
Wildlife		X	
Hydrology			X
Water Quality		X	
Noise		X	
Socioeconomics	X		
Visual Resources		X	

6. Compatibility with the Hetch Hetchy System:

The Lower Moccasin Creek Power Plant Project would be an "extension" of the Holm Powerhouse. It would reuse the water leaving Holm Powerhouse for additional power generation and would augment the water supply requirements of the City and County of San Francisco during severe drought periods by diverting water into Moccasin Reservoir. This project would preclude Project No. 8, Holm Pumping Plant and Lower Moccasin Creek Power Plant and Project No. 9, Additional Moccasin Power Plant. It would also preclude the previously proposed Clavey-Wards Ferry Project.

Project Data Sheet

Project No. 7   Project Name: Lower Moccasin Creek Power Plant

General and Technical Data

Location: From Holm Powerhouse to Moccasin Reregulating Dam

Normal Max. W.S. Elevation: 2210

Avg. Operating Head: 1100 Feet

Estimated Design Flow: 830 cfs

Installed Capacity: 65 MW

Number of Units: Two

Type of Turbine: Vertical Shaft Impulse Turbine

Load Factor: 80%

Annual Energy Productions: 460,000,000 kWH

Power Conduit, Type: Power Tunnel

Inside Diameter: 13 Feet

Penstock, Type: Steel

Avg. Diameter: 72 Inches

Total Bond Issue: $473,000,000

Project Data Sheet

Project No. 7 Project Name: Lower Moccasin Creek Power Plant
Bid Date: Mid 1984
On Line: Mid 1988

Annual Cost

(1)	Amortization and Interest Payment (9% interest - 40 years)	$ 39,883,000
(2)	Operation and Maintenance Costs ($5.19/kW x 1.08^n)	787,000
(3)	Interim Replacements Costs (1.4% of power plant cost)	449,000
(4)	Administrative and General (39% of (2))	307,000
(5)	Insurance (0.1% of Construction Cost)	319,000
(6)	Property Tax (approx. 6% net income)	1,547,000
	TOTAL	$ 43,292,000

Annual Benefit

(1)	Capacity ($69 x 1.11^n)	$ 10,336,000
(2)	Energy (0.054 x 1.11^n)	$ 57,256,000
	TOTAL	$ 67,592,000

Benefit-Cost Ratio (B/C) 1.56

First year's net income $ 24,300,000

Remarks

No loss in generation at Holm Powerhouse is calculated since generation schedule and construction schedule could be coordinated to result in a two-month downtime when Lake Lloyd is at minimum pool.

A $2 million budget item is included in the cost estimate to enlarge that portion of the existing Mountain Tunnel between Early Intake and the junction with the connecting branch of the new tunnel to carry 1100 cfs.

Preliminary Cost Estimate Summary

Bid Date: Mid 1984
On Line: Mid 1988

Project No. 7 Project Name: Lower Moccasin Creek Power Plant

Major Cost Items:	Cost (10^6 $)(1988)
Land and Land rights	-
Reservoir	-
Diversion Tunnel	-
Power Tunnel and Upstream Pipeline	228.83
Penstock	13.05
Power Plant	32.09
Access Roads	.16
Others (Bypass Conduit & Valve House, Trans. Line)	3.26
Total Direct Cost	277.40
15% Contingency	41.61
(1) Total Construction Cost	319.01
(2) Engineering and Admin. Costs (12.5%)	39.88
(3) Total Project Cost	358.89
(4) Interest During Construction, 4 yrs) (3) x IDC (0.18)	64.60
(5) Total Investment Cost ((3) +(4))	423.49
(6) Reserve Fund*	43.97
(7) Financing Expenses**	4.73
(8) Working Capital***	.95
(9) Bond Issue	473.14
Say	$473,000,000

* Reserve Fund based on one year's debt service assuming 9%-40-year level
** Based on 1% of total financing
*** Based on 0.2% of total financing

7.8 PROJECT NO. 8 - HOLM PUMPING PLANT AND LOWER MOCCASIN CREEK POWER PLANT

1. General:

The Holm Pumping Plant and Lower Moccasin Creek Power Plant Project would modify the discharge water passage of the Holm Powerhouse so that a regulating gate could be installed to allow the outflow to be discharged either into the Cherry River as is presently done, or to convey it to an adjacent pumping station. The pumped water would be conveyed in a pipeline along the City's present access road right-of-way to a location near the original Early Intake Powerhouse. From there, the pipeline would cross the Tuolumne River and connect to a new parallel Mountain Tunnel. The new Mountain Tunnel would be driven to the existing Priest Reservoir. At the upstream end of the tunnel, a connection would be made with the existing Mountain Tunnel so that the Tuolumne River water may be conveyed in either tunnel. A stub tunnel would be driven from the tunnel portal area described in Project No. 7, Lower Moccasin Creek Power Plant, to connect with the new Mountain Tunnel just upstream of Priest Reservoir. The downstream arrangement of this project would be identical to that described under Project No. 7 except that the bypass pipe to Moccasin Reservoir would not be necessary.

The positive aspects of this project would be that the parallel Mountain Tunnel would assure delivery of water to the City even though one of the tunnels is closed for maintenance purposes or closed due to stoppage from rockfalls. The existing Mountain Tunnel was inspected on November 8-9, 1980, and it was found that much of the lining, installed in the early 1920's was showing signs of deterioration. This project

would provide an opportunity for the City to repair the deteriorated portions of the existing tunnel, and to allow programmed maintenance of both tunnels in the future without disrupting the water supply to the City. A project layout is shown on Plate 6.

2. Project Features:

a. System Description: The rated flow of 830 cfs being discharged from the Holm Powerhouse would be regulated so that some, or all, of the water could enter the pumping plant. The pumps would be designed for a discharge head of about 300 feet. The preliminary arrangement selected for this study would have six 62,000 gpm pumps discharging into a 9-ft pipeline; but these preliminary figures require optimizing in future studies. The pipeline would be run along the City's access road right-of-way, and would be buried to prevent vandalism as well as be more environmentally acceptable. There would be a river crossing at Intake Switchyard from where the water would enter a new parallel Mountain Tunnel. The new Mountain Tunnel would have a gated cross-connection with the existing Mountain Tunnel so that Tuolumne River water can be conveyed into the new tunnel during high runoff periods. At the downstream end of the new tunnel, one branch would be driven to Priest Reservoir, and another branch would be driven to a new tunnel portal. The branch to Priest Reservoir would be equipped with a regulating gate to allow some, or all, of the water in the new tunnel to enter Priest Reservoir. Under normal conditions,

the regulating gate would be closed so that the water from the Holm Pumping Station would be delivered to the Lower Moccasin Creek Power Plant. During periods of drought, the regulating gate could be operated to allow supplementing the normal water supply with water from the Holm Pumping Station.

b. System Operation: During periods of high runoff in the Tuolumne River basin, there would be 1100 cfs available to both tunnels for a period of 92 days during an average year. Since the capacity of the two tunnels would be 1560 cfs, only 460 cfs would be pumped from the Holm pumping plant during the 92-day period. The most favorable operating scheme during the high runoff period of an average year would be to convey 730 cfs of Tuolumne River water into Mountain Tunnel and allow 370 cfs to be diverted into the new Mountain Tunnel. The flow in the new Mountain Tunnel would be augmented by 460 cfs derived from the Holm Powerhouse. This would enable the City to preserve 67,500 acre-feet of water at Lake Lloyd for future use. The load factor of Holm Powerhouse would be 56% during the 92-day runoff period and 73% during the remainder of the year.

c. Capacity and Energy Potential: Under a net operating head of 1350 feet with a design flow of 830 cfs, the capacity and energy potential of the project when operating at 100% load factor during the 92-day runoff period and 73% load factor during the remainder of the year would be:

	During Runoff Period	Remainder of Year
Installed Capacity	80 MW	80 MW
Energy Production	178 million kWh	386 million kWh
Annual Energy Production	564 million kWh	

However, the pumping plant would require electrical energy from the Holm Powerhouse which must be provided from the system. The power and energy usage for the pumps is estimated to be:

	During Runoff Period	Remainder of Year
Capacity	13 MW	24 MW
Energy Usage	29 million kWh	115 million kWh
Annual Energy Usage	144 million kWh	

Therefore, the system net gain would be:

Capacity	56 MW
Annual Energy Production	420 million kWh

3. Costs, Benefits and Economic Feasibility:

The total investment cost of the Holm Pumping Plant and Lower Moccasin Creek Power Plant includes the costs of modifying Holm Powerhouse, pumping station, pipeline, tunnel, penstock, power generation equipment, and the new powerhouse, switchyard, and related features. The estimated total investment cost would be $473.88 million, financed by a bond issue of $496 million. No land acquisition cost was assigned to this project since all major features are within the City's right-of-way or on City property.

The estimated annual power benefit would be $61.18 million. The benefit-cost ratio is 1.34. In addition to power benefits, this project would allow the City to meet future water delivery requirements by opening a regulating gate in the tunnel to allow as much water as needed to pass into Priest Reservoir.

4. Geotechnical Opinion:

Refer to Project No. 7 for the geotechnical opinion.

5. Environmental Checklist:

Refer to Project No. 7 for the environmental checklist.

6. Compatibility with the Hetch Hetchy System:

The Holm Pumping Plant and Lower Moccasin Creek Power Plant Project would be an extension of the Holm Powerhouse. It would reuse the water leaving Holm Powerhouse for additional power generation and would augment the water supply to the City during periods of drought. This project would provide a redundancy in the water supply system in that a parallel Mountain tunnel would be available in the event of a rockfall in one of the tunnels. This project would preclude Project No. 7, Lower Moccasin Creek Power Plant, and Project No. 9, Additional Moccasin Power Plant, as well as the previously proposed Clavey-Wards Ferry Project.

Project Data Sheet

Project No. 8   Project Name: Holm Pumping Plant and Lower Moccasin Creek Power Plant

General and Technical Data

Location: From Holm Powerhouse to Moccasin Reregulating Dam

Avg. Operating Head: 1350 Feet

Estimated Design Flow: 830 cfs

Installed Capacity: 80 MW, system net gain = 67 MW

Number of Units: Two

Type of Turbine: Vertical Shaft Impulse

Load Factor: 80% average annual

Annual Energy Production: 564,000,000 kWh, system net gain = 420,000,000 kWh

Penstock, Type: Steel

Avg. Diameter: 72 Inches

Tunnel Size: 13 Feet

Length: 110,000 Feet

Pipeline, Size: 9 Feet

Total Bond Issue: $496,000,000

Project Data Sheet

Project No. 8 Project Name: Holm Pumping Plant & Lower Moccasin Creek Power Plant
Bid Date: Mid 1984
On-Line: Mid 1988

Annual Cost

(1)	Amortization & Interest (Payment (9% int-40 years)	\$41,822,000
(2)	Operation and Maintenance Costs (\$5.19/kW x 1.08^n)	811,000
(3)	Interim Replacement Costs	518,000
(4)	Administrative and General (39% Of (2))	316,000
(5)	Insurance (0.1% of construction cost)	334,000
(6)	Property Tax (approx. 6% net income)	1,980,000
	TOTAL	45,781,000

Annual Power Benefit

(1)	Capacity \$69/1.11^n	8,906,000
(2)	Energy (\$0.054 x 1.11^n)	52,277,000
	TOTAL	61,183,000

Benefit-Cost Ratio (B/C)	1.34
First year's net income	\$15,402,000

Remarks

No loss in generation at Holm Powerhouse is calculated since generation schedule and construction schedule could be coordinated to result in a two-month downtime when Lake Lloyd is at minimum pool. A \$2 million budget item is included in the estimate to enlarge that portion of the existing Mountain tunnel between Early Intake and the junction with the new Mountain Tunnel to carry 1100 cfs.

Preliminary Cost Estimate Summary

Bid Date: Mid 1984
On Line: Mid 1988

Project No. 8 Project Name: Holm Pumping Plant and Lower Moccasin Creek Power Plant

Major Cost Items:	Cost (10^6 x \$) 1988
Land and Land rights	
Reservoir	
Pumping Plant	10.77
Pipeline	12.40
Power Tunnel	216.53
Penstock	13.05
Power Plant	37.03
Access Roads	0.16
Others (Trans. Line)	0.82
Total Direct Cost	290.76
15% Contingency	43.61
(1) Total Construction Cost	334.37
(2) Engineering and Admin. Costs (12.5%)	41.80
(3) Total Project Cost	376.17
(4) Interest During Construction, (4 yrs) (3) x IDC factor (0.18)	67.71
(5) Total Investment Cost ((3) + (4))	443.88
(6) Reserve Fund*	46.11
(7) Financing Expenses**	4.96
(8) Working Capital***	.99
(9) Bond Issue	495.94
Say	$ 496,000,000

* Reserve Fund based upon one year's debt service assuming 9%-40 year level
** Based on 1% of total financing
*** Based on 0.2% of total financing

7.9 PROJECT NO. 9 ADDITIONAL MOCCASIN POWER PLANT

1. General:

The Additional Moccasin Power Plant Project would convey the outflow from the Holm Powerhouse through a new tunnel to an additional powerhouse located at the present parking area for the original Moccasin Powerhouse. The discharges from this new powerhouse would flow into Moccasin Creek through a concrete conduit located along the north bank of the Moccasin Re-regulating Reservoir and through the north abutment of the Moccasin Dam. A regulating gate would be installed in the concrete conduit to allow water to enter Moccasin Reservoir during periods of drought. The power plant would operate in tandem with the Holm Powerhouse units. The positive aspect of this project is that water which is now conveyed in Mountain Tunnel could be conveyed in the new tunnel for a period of one or two years to upgrade the condition of the Mountain Tunnel. The existing Mountain Tunnel was inspected on November 8-9, 1980, and it was found that much of the lining, installed in the early 1920's was showing signs of deterioration. This project would provide an opportunity for the City to repair the deteriorated portions of the existing tunnel, and to allow programmed maintenance of both tunnels in the future without disrupting the water supply to the City. The basic advantage of this Project over Project No. 8 is the elimination of the pumping power required in Project No. 8. A project layout is shown on Plate 5.

2. Project Features:

a. Power Tunnel and Penstock: The water conveyance system would consist of the following features: Modification of the

discharge water passage at Holm Powerhouse so that the outflow could be regulated to either discharge the water into the Cherry River as is presently being done, or to divert discharges into a pipeline. The pipeline would be located on the right bank of the Cherry River and would be about 1,500 feet long. The water would then be conveyed into a tunnel at a portal located near the spoil area which was used during the construction of Holm Powerhouse. The tunnel would have a total length of approximately 110,000 feet and would follow the alignment of the existing Mountain Tunnel after crossing the Tuolumne River. This tunnel would be about 100 feet below the existing mountain tunnel; therefore, a connection could be made to allow water that could not be conveyed in Mountain Tunnel to spill into the new tunnel. The downstream tunnel portal would be about 5000 feet upstream of the powerhouse at elevation 2000 feet. The water would then be conveyed in a steel penstock. This penstock would bifurcate just upstream of the powerhouse into two penstocks to serve two units in the new powerhouse. This layout would result in a gross head of about 1280 feet and would carry a design flow of 830 cfs for power generation. Due to environmental concerns, the tunnel portal would be placed out-of-sight of Highway 120. The penstock would cross under the present Moccasin penstocks, and be buried at its lower reaches.

b. Powerhouse: The Additional Moccasin Powerhouse would be a typical reinforced concrete powerhouse containing two power generating units driven by vertical impulse turbines. A synchronous pressure relief valve would be installed in the powerhouse to release high pressure water in case of power equipment malfunctions. A switchyard would be constructed east of the original Moccasin Powerhouse. This arrangement would concentrate the power generation facilities within Moccasin Village, thereby allowing an ease of operating and maintenance functions as well as policing activities.

c. System Operation: During periods of high runoff on the Tuolumne River basin there would be 1100 cfs available to both tunnels for a period of 92 days in an average year. Since the capacity of the existing Mountain Tunnel is 730 cfs, 370 cfs could be transferred into the new tunnel. The most favorable operating scheme during the high runoff period would be to operate Holm Powerhouse with 460 cfs; thereby preserving 67,500 acre-feet in Lake Lloyd for future use. The load factor of Holm Powerhouse would be 56% during the 92-day runoff period and 73% during the remainder of the year.

d. Capacity and Energy Potential: Under a net operating head of 1050 feet with a design flow of 830 cfs, the capacity and energy potential of the project when operating at 100 % load factor during the 92-day runoff period and 73% load factor during the remainder of the year would be:

	During Runoff Period	Remainder of Year
Installed Capacity	63 MW	63 MW
Energy Production	139 million kWh	301 Million kWh
Annual Energy Production	440 million kWh	

3. Costs, Benefits, and Economic Feasibility:

The total investment cost of the Additional Moccasin Power Plant includes the costs of modifying Holm Powerhouse, tunnel, penstock, powerhouse, power generation equipment, pressure regulator, switchyard and all related facilities. The estimated total investment cost would be $421.5 million, financed by a bond issue of $471 million. No land acquisition cost was assigned to this project since the proposed tunnel is either in the Stanislaus National Forest or within the present right-of-way of Mountain Tunnel, and the powerhouse would be located on City property.

The estimated average annual power benefit would be $64.79 million. The benefit-cost ratio is 1.51. In addition to power benefits, this project would allow the City to meet future water delivery requirements by opening a regulating gate at the powerhouse to allow as much water as needed to pass into Moccasin Reservoir. There is the added benefit in that water could be continuously supplied to the City during a period when the Mountain Tunnel could be repaired.

4. Geotechnical Opinion:

About one-third of the tunnel, from just downstream of Holm Power Plant to just west of the South Fork of the Tuolumne River, would be in granitic rock with conditions very similar to those encountered in the Mountain Tunnel. The remaining two-thirds of the tunnel, from the South Fork to Moccasin, would be in late Paleozoic-age metasedimentary rocks of the Calaveras Formation. These would primarily include phyllite and schist with some metachert, quartzite, and marble.

At the upstream end of the tunnel, part of a waste area containing material excavated during construction of Holm Power Plant would have to be excavated to establish the tunnel portal. Also, the portal area could accommodate very little additional waste material, so the first mile of the tunnel may have to be driven in an upstream direction, by first driving a temporary access incline having its portal at the Early Intake Switchyard area. The latter area was the spoil area for tunnel muck from the upstream end of the Mountain tunnel, and it would be possible to accommodate the additional muck from the new tunnel at this location.

The new tunnel could be excavated by use of tunnelling machines, one starting at the upstream end (at Early Intake) and one at the downstream end near Moccasin. The downstream tunnel should be driven oversize so that it could accommodate concrete lining where necessary for stability in certain portions of the metamorphic rock. However, the regional trend of the metamorphic foliation is steeply dipping and striking roughly perpendicular to the tunnel alignment, and this is favorable for tunnel stability.

To provide an area for tunnel muck at the downstream end of the tunnel, a temporary portal could be established in a southwestward-flowing stream drainage area located between Priest Reservoir and the existing Moccasin Power Plant penstock.

Bedrock at the location of the proposed new power plant is at, or relatively near, the ground surface. It is part of the Jurassic-age Mariposa slate formation which strikes northwest and dips steeply northeast. The Mariposa slate is in fault contact with the Calaveras Formation along a strand of the Melones fault zone at this location. The new Moccasin Power Plant penstocks would cross this fault strand, as do the existing power plant penstocks.

There are apparently no seriously adverse geologic conditions, which would significantly impact the suitability of the proposed new facilities, along the proposed tunnel alignment.

5. Environmental Checklist:

Category	Insignificant or Minor Impacts	Mitigable Impacts	Potentially Significant Impacts
Land Use Compatibility	X		
Special Use Designations	X		
Vegetation		X	
Wildlife		X	
Hydrology			X
Water Quality		X	
Noise		X	
Socioeconomics	X		
Visual Resources		X	

6. Compatibility with the Hetch Hetchy System:

The Additional Moccasin Power Plant Project would be an extension of the Holm Powerhouse. It would reuse the water leaving Holm Powerhouse for additional power generation and would augment the water supply requirements of the City and County of San Francisco during severe drought periods by diverting water into Moccasin Reservoir. This project would preclude Projects No. 7 and 8. It would also preclude the previously proposed Clavey-Wards Ferry Project in that this project would utilize the major source of water that was proposed to be used.

Project Data Sheet

Project No. 9 Project Name: Additional Moccasin Power Plant

General and Technical Data

Location: From Holm Powerhouse to Moccasin Re-regulating Dam

Dam, Type: Existing

Normal Max. W.S. Elevation: 2210

Avg. Operating Head: 1050 Feet

Estimated Design Flow: 830 cfs

Installed Capacity: 63 MW

Number of Units: Two

Type of Turbine: Vertical Shaft Impulse Turbine

Load Factor: 80%

Annual Energy Productions: 440,000,000 kWh

Power Conduit, Type: Power Tunnel

Inside Diameter: 13 Feet

Penstock, Type: Steel

Avg. Inside Diameter: 72 Inches

Total Bond Issue: $471,000,000

Project Data Sheet

Project No. 9 Project Name: Additional Moccasin Power Plant
Bid Date: 1984
On Line: 1988

Annual Cost

(1) Amortization and Interest Payment (9% interest - 40 years)	39,714,000
(2) Operation and Maintenance Costs ($5.19/kW \times 1.08^n$)	762,000
(3) Interim Replacement Costs (1.4% of power plant cost)	449,000
(4) Administrative and General (39% of (2))	297,000
(5) Insurance (0.1% of construction cost)	318,000
(6) Property Tax (approx. 6% net income)	1,447,000
TOTAL	42,987,000

Annual Power Benefit

(1) Capacity ($\$69 \times 1.11^n$)	10,020,000
(2) Energy ($\$0.054 \times 1.11^n$	54,767,000
TOTAL	64,787,000
Benefit-Cost Ratio (B/C)	1.51
First year's net income	21,800,000

Remarks

No loss in generation at Holm Powerhouse is calculated since generation schedule and construction schedule could be coordinated to result in a two-month downtime when Lake Lloyd is at minimum pool. A $2 million budget item is included in the estimate to enlarge that portion of the existing Mountain Tunnel between Early Intake and the junction with the connecting branch of the new tunnel to carry 1100 cfs.

Preliminary Cost Estimate Summary

Bid Date: Mid 1984
On-Line: Mid 1988

Project No. 9 Project Name: Additional Moccasin Power Plant

Major Cost Items:	Cost (10^6 x $) (1988)
Land and Land rights	-
Reservoir	-
Diversion Tunnel	-
Power Tunnel and Upstream Pipeline	228.83
Penstock	9.30
Power Plant	32.09
Access Roads	0.16
Others (Bypass Conduit)	5.71
Total Direct Cost	276.09
15% Contingency	41.41
(1) Total Construction Cost	317.51
(2) Engineering and Admin. Costs (12.5%)	39.69
(3) Total Project Cost	357.20
(4) Interest During Construction, (4 yrs) (3) x 1DC (0.18)	64.30
(5) Total Investment Cost ((3) +(4))	421.50
(6) Reserve Fund*	43.78
(7) Financing Expenses**	4.71
(8) Working Capital***	.94
(9) Bond Issue	470.93
Say	$471,000,000

* Reserve Fund based on one year's debt service assuming 9%-40-year level
** Based on 1% of total financing
*** Based on 0.2% of total financing

7.10 PROJECT NO. 10 MARSHS FLAT PUMPED-STORAGE SCHEME

1. General:

By constructing an upper reservoir at Marshs Flat and a lower reservoir on Moccasin Creek upstream of the Moccasin Reservoir, a pumped-storage scheme could be developed. Water for the initial filling of the project could be released from Priest Reservoir down Rattlesnake Creek; thereby filling the lower reservoir. Makeup water for evaporation and seepage would normally be available from the natural flow in Moccasin Creek. However, for the sake of conservatism, a small pumping plant would be installed at the Moccasin Reservoir to allow makeup water to be available at all times.

The Marsh's Flat Pumped Storage project would be as shown on Plate 7 and would consist of:

a. An upper reservoir on Marshs Flat.

b. A lower reservoir on Moccasin Creek.

c. A powerhouse containing reversible pump turbines located at the lower reservoir.

d. A power tunnel and penstock connecting the powerhouse with the upper reservoir.

2. Project Features:

a. The Upper reservoir: Marshs Flat Reservoir would be located approximately one mile south of the Moccasin Re-regulating Dam at an elevated meadow which is privately owned. The reservoir would be formed by constructing 3 dams. All 3 dams would be of the earthfill embankment type. The maximum water surface would be at elevation 1910'. The reservoir would have a live storage

capacity of 11,470 acre-feet. Dam C would contain an emergency spillway to allow excess water to pass into Hatch Creek, and from there into Don Pedro Lake.

b. Lower Reservoir: Moccasin Creek Reservoir would be located approximately 3000 feet upstream of the Moccasin Reregulating Dam. The dam would be a 185 feet high overflow concrete gravity dam with a crest length of 1550 feet. Approximately 3 miles of Highway 49 would be relocated to accommodate the lower reservoir. The initial filling of this lower reservoir would be by releasing water from the low level outlet at Priest Dam. After the initial filling, natural flows into the lower reservoir are expected to be adequate to keep it full; however, a contingency pumping plant is estimated for this study.

c. Powerhouse: The powerhouse would be of reinforced concrete construction housing reversible pump turbines of the Francis type. The total generating capacity would be 1000 MW.

d. Power intake: The intake at the upper reservoir would be located near Dam B. The intake would be drop inlets with three 100-foot vertical shafts discharging into three 24-foot diameter power tunnels at elevation 1750'. Six steel penstocks would carry the flow to the powerhouse. The penstocks would be 5600 feet in length. This layout would result in an average gross head of 760 feet for pumping and power generation.

e. Transmission Line: A completely new transmission line would be required for this project. In order to estimate the cost of the transmission line, it was assumed that a single-circuit 500 kV line would be constructed to Pacific Gas and Electric's

Tesla substation, the logical terminus for the acquisition of pumping energy.

f. Capacity and Energy Potential: The capacity and energy potential of the project when generating at an average load factor of 25% (or 6 hours a day) would be:

Installed Capacity = 1000 MW

Annual energy production = 2190 million kWh

However, the pumping cycle would require an energy usage of 3285 million kWH annually.

3. Costs, Benefits, and Economic Feasibility:

The total investment cost of the Marshs Flat Pumped Storage Scheme includes dams (upper and lower), reservoir preparation and clearing, land and land rights, spillway, intake and outlet, power tunnel, penstock, pumping station and discharge pipe, highway relocation, powerhouse, power generation equipment, and transmission line. The estimated total investment cost would be $888 million.

The estimated average annual power benefit would be $446.69 million, financed by a bond issue of 992.5 million. However, 378.52 million dollars is required for the purchase of pumping energy per year. The benefit-cost ratio is 0.89.

4. Geotechnical Opinion:

The Marshs Flat damsites are located west of the Melones fault zone within a broad band of steeply dipping metamorphic formations, which have been intruded by igneous rocks of various compositions. The proposed dam axis of Dam B, in relation to geologic units is lying within a northwest-trending narrow band of diorite. A metavolcanic formation known as the

Penon Blanco Volcanics occurs on both sides of the diorite. The eastern contact is mapped as an intrusive contact and the western contact, as a fault. The proposed axis of the Dam A lies within the Penon Blanco Formation, which forms resistant ridges in this area.

In accord with regional trends, the Penon Blanco Formation strikes northwest and dips steeply northeast in the area of the Marshs Flat damsites. The fault that forms the contact between diorite and metavolcanic rock, just west of the Dam B axis, locally follows this trend; but to the northwest, it curves more toward the west and forms an acute angle with the regional trend until it joints the Bear Mountains fault zone northeast of Hetch Hetchy Junction. A strand of the Melones fault zone is located about one-third mile northeast of Dam A, where it forms the contact between the Penon Blanco Volcanics and the Mariposa Formation slates and graywackes. The Bear Mountains and Melones fault zones are part of the Foothills fault system, which runs along the western margin of the Sierra Nevada range.

Rock outcrops in the vicinity of Marshs Flat damsites are scarce and occur as "tombstone" outcrops, which commonly are completely surrounded by strongly weathered and decomposed rock. For the 70-foot-high Dam B, the foundation for an embankment dam could be developed on firm, but weathered, rock, which is estimated to be about 10-feet deep on the abutments and 15- to 20-feet deep across the center of the valley. For the 170-foot-high west Dam A, a zoned embankment might be considered. Estimated foundation excavation requirements for the shell zones are 5 to 10 feet on the abutments and 10 to 15 feet (to in-place weathered rock) across the valley bottom. Core-zone cutoff excavation should extend to groutable rock (rock sufficiently fresh to contain openings along

discontinuities), which is estimated to be 10 to 15 feet on the abutments and 15 to 25 feet in the valley. Curtain grouting requirements are estimated to be light for all the dams. The geologic structure is steeply dipping and roughly parallel with the dam axis, so the potential for grout travel would tend to be along the plane of the grout curtain.

On the basis of geologic data obtained from the present limited reconnaissance study, the Marshs Flat Reservoir site appears to be suitable for embankment dams of the sizes being considered. There is no evidence to suggest that reservoir leakage would be a significant problem. The fault mapped by others just west of Dam B, would have to be investigated as to its exact location, width, and possible potential for activity in order to provide a better assessment of the fault's significance to the proposed dam.

The lower dam for the Marshs Flat Pumped Storage Scheme would be located on a northwest-trending zone of vertical to steeply dipping slate of the Mariposa Formation. A major branch of the Melones fault zone runs parallel with Moccasin Creek just upslope from the right abutment of the proposed dam. Moccasin Creek at this location is also parallel with the strike of the Mariposa Formation slate. The creek bed is filled with alluvium and dredge tailings over a width of several hundred feet. Maximum depth of alluvium could be in excess of 50 feet. Preliminary estimates of stripping requirements for the foundation of a concrete gravity dam would include removal of all dredge tailings and alluvium and additional excavation to remove strongly weathered slate bedrock. Though the slate is hard and sound where fresh, the planes of schistocity, in combination with joints and fractures, allow weathering to penetrate the rock up to depths of 50 feet or more. Exploratory drilling and trenching

prior to design of this lower dam would be required to assess whether the proposed concrete structure or an embankment dam would be the most economical. Foundation grouting requirements for either type of dam would be light to moderate. Because the bedding planes and slatey cleavage of the bedrock is vertical to steeply dipping and strikes perpendicular to the proposed dam axis, curtain grout holes should be inclined in the plane of the grout curtain. On the basis of the data obtained from the present reconnaissance study, this site appears to be suitable for a concrete gravity dam. Future subsurface exploration may indicate that an embankment dam would be more economical. Exploration should also be directed toward the possibility that additional, presently unmapped, branches of the Melones fault zone might exist in the dam foundation area.

5. Environmental Checklist:

Category	Insignificant or Minor Impacts	Mitigable Impacts	Potentially Significant Impacts
Land Use Compatibility			X
Special Use Designations	X		
Vegetation		X	
Wildlife		X	
Hydrology		X	
Water Quality		X	
Noise		X	
Socioeconomics		X	
Visual Resources	X		

6. Compatibility with the Hetch Hetchy System:

Marshs Flat Pumped Storage Scheme would be an independent improvement; it would not preclude another project. This project would add 2190 million kWh of peaking power annually to the Hetch Hetchy Power System, if the off-peak pumping energy could be found and purchased. The project is compatible with the present Hetch Hetchy system and would not affect, nor be affected by the proposed Clavey-Wards Ferry Project.

Project Data Sheet

Project No. 10   Project Name: Marshs Flat Pumped Storage

General and Technical Data

Location: One mile upstream of Moccasin Powerhouse

Dam, Type: (Upper) Earthfill
(Lower) Concrete Gravity

Height: (Upper) 170' & 70' & 20'
(Lower) 185'

Approx. Crest Length: (Upper) 1700' and 1000' and 200'
(Lower) 1550'

Normal Max. W.S. Elevation: (Upper) 1910
(Lower) 1170'

Avg. Operating Head: 720 Feet

Estimated Design Flow: 20,415 cfs

Installed Capacity: 1,000 MW

Number of Units: 6

Type of Turbine: Francis Type Pump-turbine

Load Factor: 25%

Annual Energy Productions: 2,190,000,000 kWh

Spillway, Type: (Upper) Uncontrolled Ogee
(Lower) Uncontrolled Ogee

Power Conduit, Type: Power tunnel, 3 required

Diameter: 24'

Penstock, Type: Steel, 6 required

Avg. Dia.: 14.5'

Total Bond Issue: $ 992,500,000

Project Data Sheet

Project No. 10 Project Name: Marshs Flat
Bid Date: 1984
On Line: 1988

Annual Cost

(1)	Amortization and Interest Payment (9% interest - 40 years)	83,686,000
(2)	Operation and Maintenance Costs ($5.19/kW \times 1.08^n$)	12,101,000
(3)	Interim Replacement Costs (1.4% of power plant cost)	3,746,000
(4)	Administrative and General (39% of (2))	4,719,000
(5)	Insurance (0.1% of construction cost)	669,000
(6)	Cost of Pumping Energy ($.05/kWh \times 1.11^n$)	378,520,000
(7)	Transmission Loss 5% of (6)	18,926,000
(8)	Property Tax (approx. 6% net income)	-
	TOTAL	502,367,000

Annual Power Benefit

(1)	Capacity ($\$69 \times 1.11^n$)	159,013,000
(2)	Energy ($\$0.060 \times 1.11^n$)	302,816,000
(3)	Power Loss 5%	- 15,140,000
(4)	Total Annual Benefit	446,689,000

Benefit-Cost Ratio (B/C)	.89
First year's net income	- 55,678,000

Remarks

The powerhouse daily operation schedule was assumed to be 6 hours on-peak generation and 9 hours off-peak pumping. An underground powerhouse was

not studied during this initial study because it was considered doubtful that the metamorphic formations would support an underground cavern of the necessary size.

Preliminary Cost Estimate Summary

Bid Date: Mid 1984
On-Line: Mid 1988

Project No. 10 Project Name: Marshs Flat Pumped Storage

Major Cost Items:	Cost (10^6 x $) (1988)
Land and Land rights	4.05
Reservoir	1.40
Dam: a) Earthfill (or Rockfill)	32.68
b) Concrete	46.71
Spillway	2.19
Intake and Outlet	16.31
Power Tunnel	37.93
Penstock	62.52
Power Plant	267.56
Highway Relocation	5.19
Transmission Line	104.41
Others (pumps and pipeline)	0.86
Total Direct Cost	581.81
15% Contingency	87.27
(1) Total Construction Cost	669.08
(2) Engineering and Admin. Costs (12.5%)	83.64
(3) Total Project Cost	752.72
(4) Interest During Construction, (4 yrs) (3) x 1DC (0.18)	135.49
(5) Total Investment Cost ((3) +(4))	888.21

(6)	Reserve Fund*	92.26
(7)	Financing Expenses**	9.93
(8)	Working Capital***	1.99
(9)	Bond Issue	992.39
	Say	$992,500,000

* Reserve Fund based on one year's debt service assuming 9%-40-year level
** Based on 1% of total financing
*** Based on 0.2% of total financing

SECTION 8

UPRATING INVESTIGATIONS

SECTION 8

UPRATING INVESTIGATIONS

8.1 General:

As part of the Systemwide Power Study, the possibility of increasing the output of the existing generating units was investigated. The investigation considered the possibility of increasing turbine output, the possibility of increasing generator output, or replacing coils to increase the generator output. The capabilities of generator breakers, generator leads, and transformer to carry a 10-percent load increase were also investigated. The results of the investigation are described below:

8.2 Holm Powerhouse Generating Units:

The investigations show that the output of the Holm Powerhouse units are limited by the turbine capability. The generator coils have experienced several failures in the past, and may have to be replaced if the failures persist. The existing generator coils have asphalt-mica insulation which has a lower dielectric strength than the newer epoxy insulation. The epoxy insulation can provide the same insulating qualities with a thinner coating than the asphalt-mica insulation. However, in rewinding existing generators, the slot area is fixed, and the volume of the slot must be taken up by either copper or insulation. Information received from the National Electric Coil Company indicates that generators having slot openings designed for coils using asphalt-mica insulation could be uprated as much as 15 percent, by using more copper, with little effect on the bid price because of the cost similarities of epoxy insulation material and copper.

Based on the above, it is recommended that when the City prepares the specifications for rewinding the Holm generators, the specifications should

call for a 10 percent increase in rating. This will assure that all manufacturers will bid a price the same as if the specifications called for the present rating of the generators. It will also allow the generators to operate at a lower temperature, thereby resulting in a longer life span of the new coils.

8.3 Kirkwood Powerhouse Generating Units:

The investigations show that the turbine needle valves are at about 85 percent of capacity when operating near the maximum recommended output of 115 percent of rated generator capability. The recorded generator coil temperatures indicate that the temperature rise at this loading is well below the maximum allowable, and extrapolation of the temperatures indicate that these units could be overloaded by about another 10 percent. The generator breakers and generator leads have the capability to carry the additional load. The transformers appear to be the weak link in the chain, and it is recommended that the City investigate the possibility of installing additional fans on the transformers.

8.4 Moccasin Powerhouse Generating Units:

The investigations show that the turbine needle valves are at about 80 percent of capacity when operating near the maximum recommended output of 115 percent of rated generator capability. The recorded generator coil temperatures indicate that increasing the generator output by another 10 percent would result in temperature rises approaching 80 degrees C, and would be marginal. The generator breakers and generator leads would be able to carry another 10 percent increase in load. The transformer operating temperatures were not investigated in detail after it was determined that increasing the generator loadings would be marginal. In applying the philosophy that, "if a machine is working well, do not tamper with it," it is recommended that loading of the Moccasin units remain as at present.

SECTION 9

OTHER PROJECTS CONSIDERED

SECTION 9

OTHER PROJECTS CONSIDERED

9.1 General:

During the initial stages of study, numerous projects were considered; however, due to their infeasibility or other shortcomings, many projects were eliminated. This section describes the projects that were eliminated from consideration so that any future studies may benefit from the experience gained during the course of this study.

9.2 Additional Kirkwood Powerhouse: A new generating unit, with its separate penstock, would be located upstream of the existing powerhouse. This project was eliminated because it was found to be more economical to use the existing penstock branch leading to the bypass valve.

9.3 Additional Unit at Holm Powerhouse. This project would have required lining the existing Cherry Power Tunnel, which would have meant a downtime of at least 6 months. The loss of revenue during the 6 months made this project economically infeasible.

9.4 Tap Lake Eleanor: This project would provide a new tunnel from Lake Eleanor to the Cherry Valley valve house for operating Holm Powerhouse during the spring. This project was eliminated because it was not as economically feasible as the Eleanor-Cherry Tunnel pumping scheme studied by the City. This project also would require some intricate valving arrangement at the valve house.

9.5 Additional Unit at Moccasin Powerhouse. This project was eliminated because of the restricted size of the Moccasin Reservoir. Various alternates were studied; such as, adding gates to the spillway and remodeling the outlet box structure to reduce head losses. However, it was found that an additional

unit could only be logical in terms of the water supply aspects of the Hetch Hetchy system, if an additional 300 acre-feet of storage could be made available without raising the tailwater above El. 922.

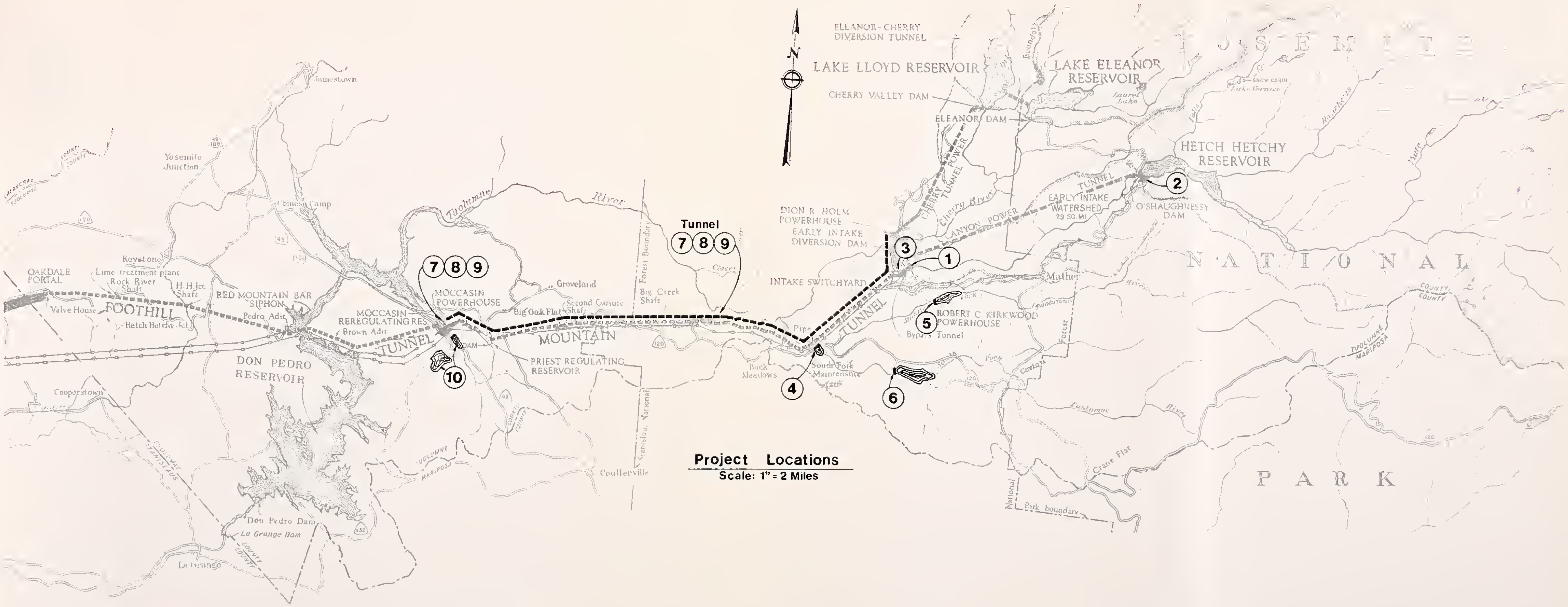
9.6 Powerhouse at Early Intake Dam. This project was eliminated because of the excessive cost in constructing an acceptable intake at the existing dam. If this dam is ever reconstructed or modified due to its deterioration with age, a power generating station having a capacity of about 2 MW should be considered.

9.7 Dam and Powerhouse at Jackass Creek. This project would have provided a tunnel from Holm Powerhouse to Jackass Creek, just south of Priest Reservoir. A dam would be constructed on Jackass Creek, serving a powerhouse located on Moccasin Creek. During drought periods, some of the water could be conveyed into Moccasin Reservoir rather than being diverted around the reservoir. This project was eliminated because it was not economically feasible.

9.8 Constructing New Priest Dam. This project would have constructed a new dam downstream of the existing dam. The reservoir capacity would be increased for more flexible operation, and the height would allow filling above the presently-restricted elevation of 2210'. This project was eliminated because it was not economically feasible.

SECTION 10

DRAWINGS



Project Locations
Scale: 1" = 2 Miles

Location Map
Scale: 1" = 21 Miles

Hydroelectric Power Projects Studied

Project No.	Project Title
1	Kirkwood Powerhouse Addition
2	Raising O'Shaughnessy Dam with Kirkwood Powerhouse Addition
3	Early Intake Powerhouse Replacement
4	South Fork Tuolumne
5	Tawonga Camp Project
6	Harden Flat Dam and Power Plant
7	Lower Moccasin Creek Power Plant
8	Holm Pumping Plant and Lower Moccasin Creek Power Plant
9	Additional Moccasin Power Plant
10	Marshs Flat Pumped-Storage Scheme

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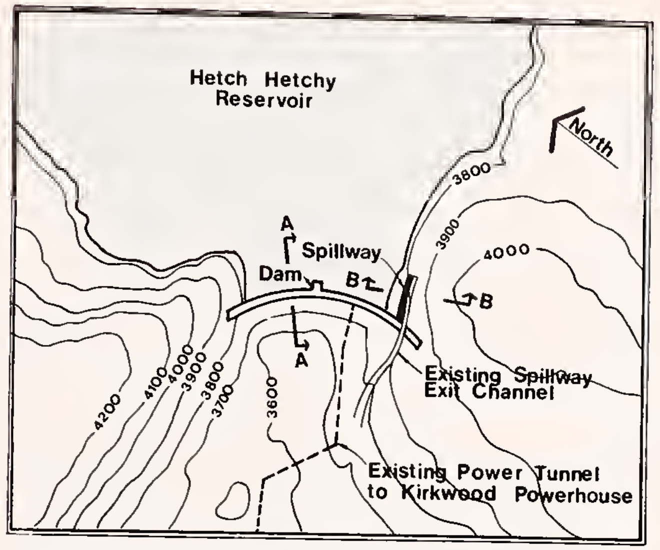
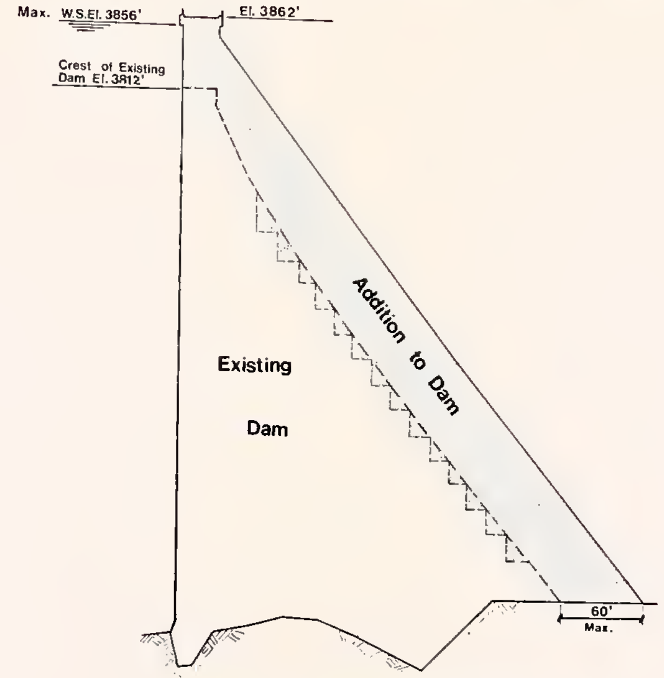
ENGINEERS - ARCHITECTS
SAN FRANCISCO, CALIFORNIA

HETCH HETCHY WATER AND POWER
SYSTEMWIDE POWER STUDY
LOCATION MAP OF PROJECTS

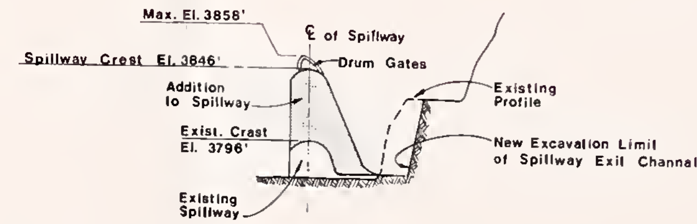
SCALE AS SHOWN | DATE FEB 98
DRAWN J.A.R.
CHECKED J.M.K.



Plan-O'Shaughnessy Dam (Project No.2 Only)
Scale: 1" = 400'



Section of Raised Dam at A-A
Scale: 1" = 60'



Section of Raised Spillway at B-B
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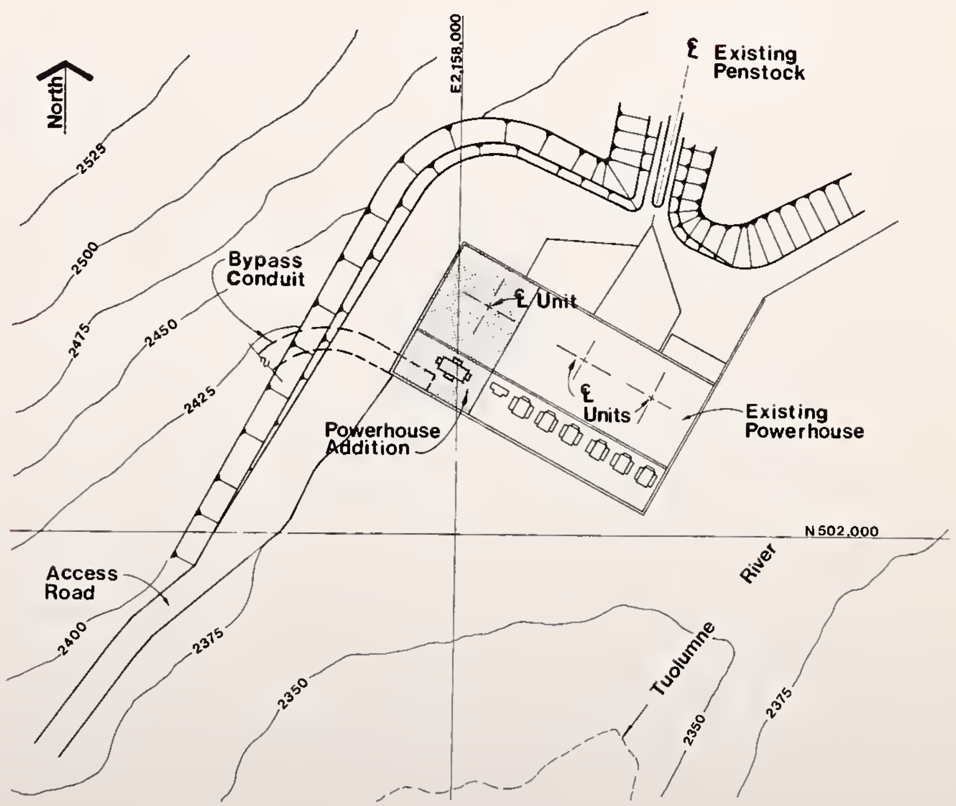

Plan-Kirkwood Powerhouse Addition
No Scale

REVISION	DATE	DESCRIPTION	BY	APPD

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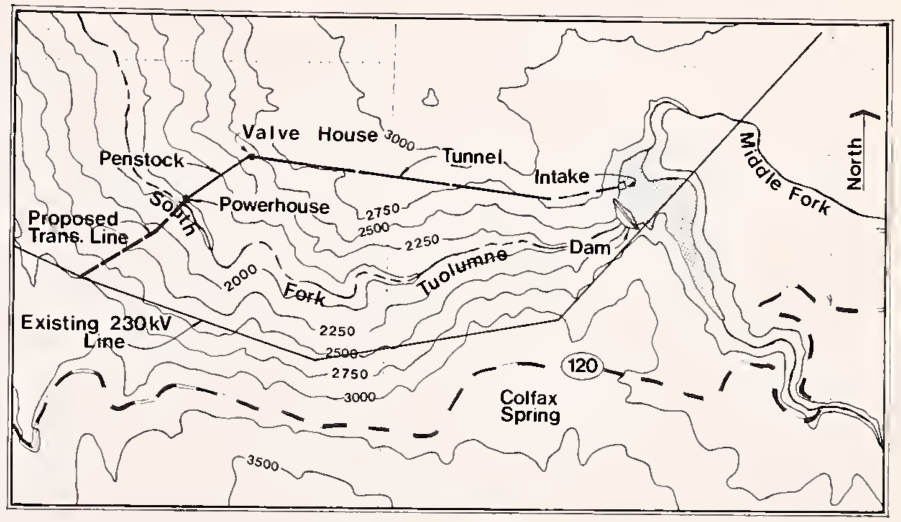
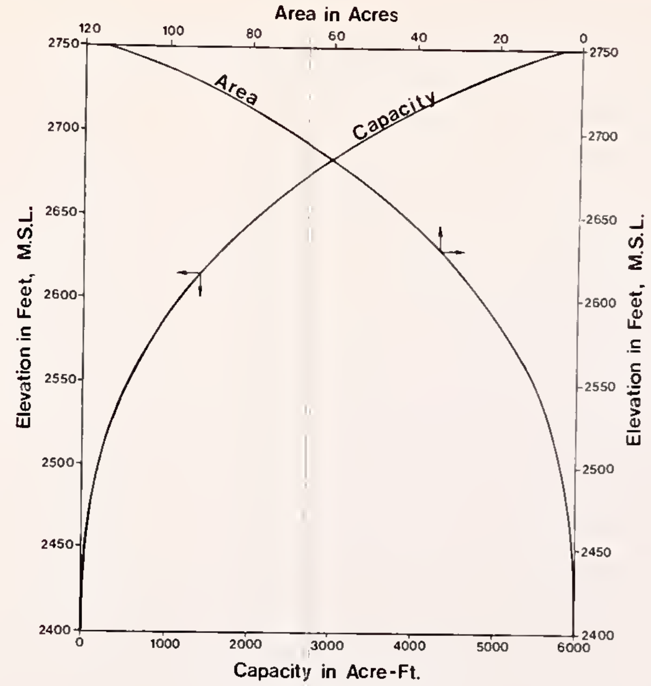
HETCH HETCHY WATER AND POWER
SYSTEMWIDE POWER STUDY
PROJ. NO. 1 KIRKWOOD POWERHOUSE ADD'N.
PROJ. NO. 2 RAISING OF O'SHAUGHNESSY DAM

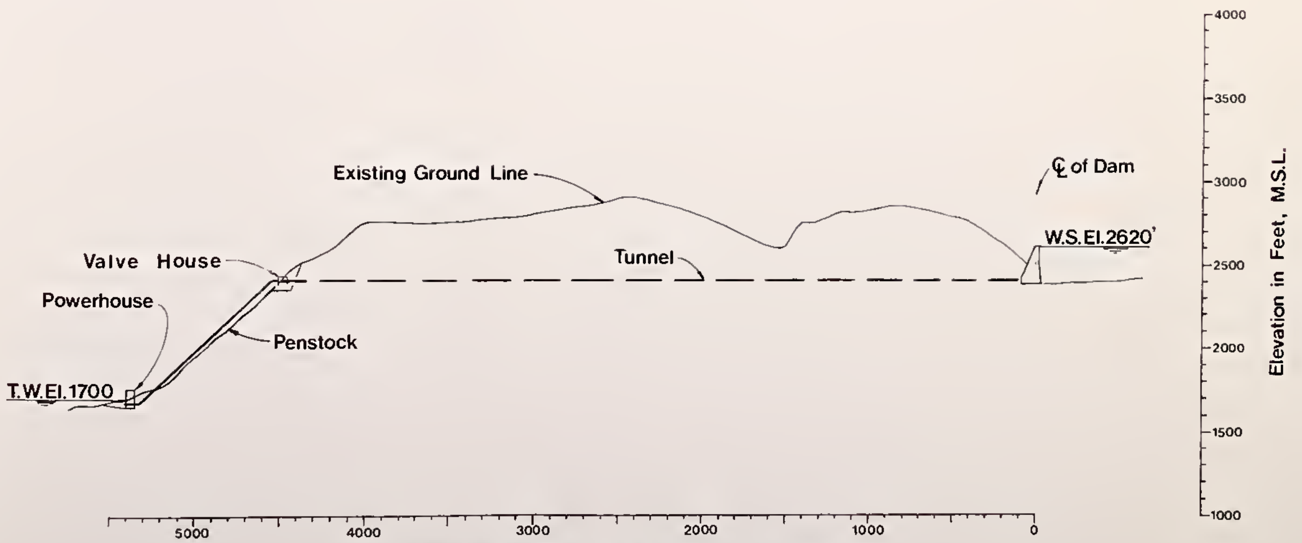
SCALE AS SHOWN	SUBMITTED		DATE FEB 1985
DESIGNED YMC		SVERDRUP & PARCEL AND ASSOCIATES, INC.	DRAWING NO.
DRAWN RGL	APPROVED		
CHECKED JMN			



Site Plan
Scale:1"=1000'



Area Capacity Curves



Profile Along ℄ of the Power Conduit
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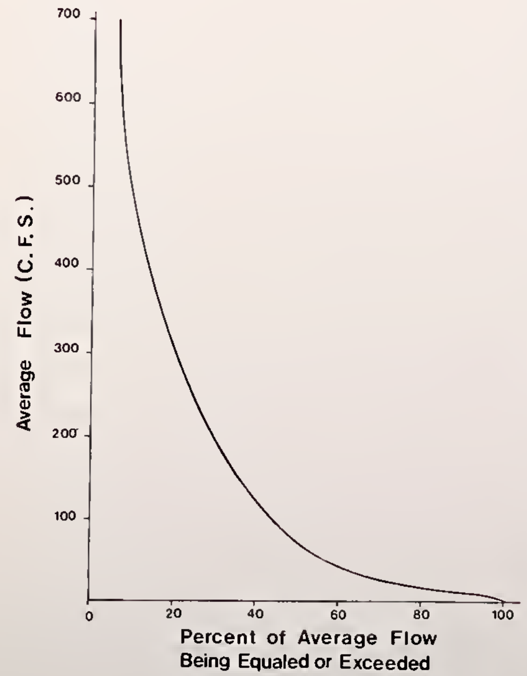

Flow Duration Curve

REVISION	DATE	DESCRIPTION	BY	APPD

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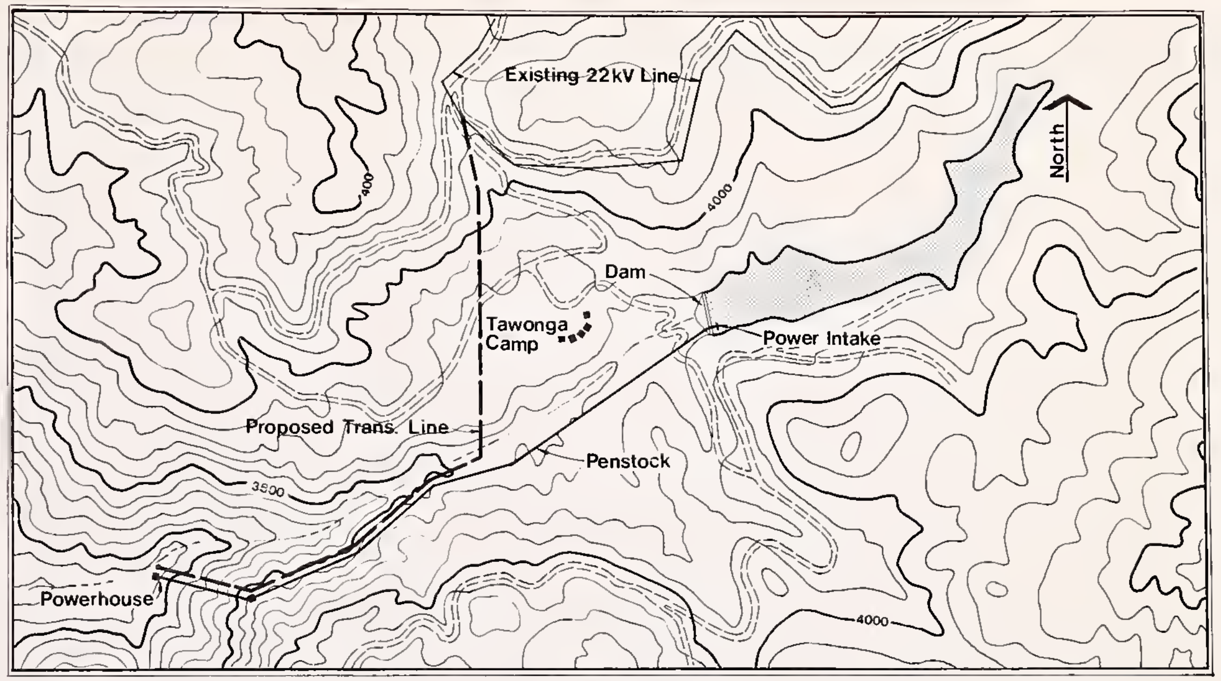
SAN FRANCISCO, CALIFORNIA

HETCH HETCHY WATER AND POWER
SYSTEMWIDE POWER STUDY

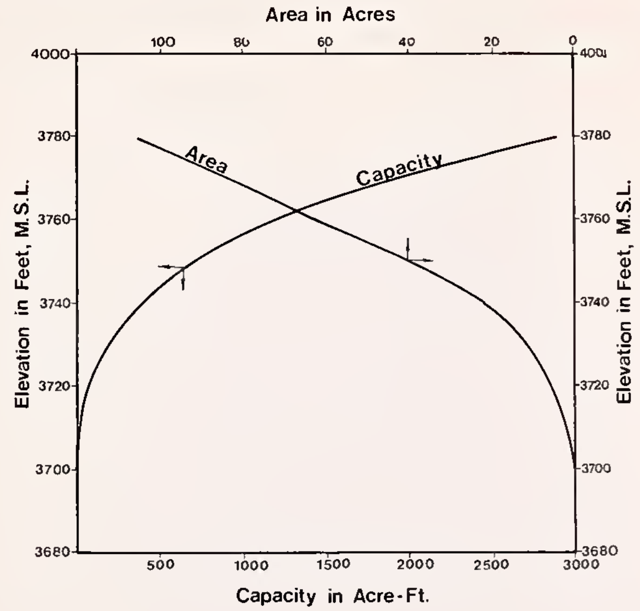
PROJECT NO. 4 SOUTH FORK TUOLUMNE

SCALE	SUBMITTED	DATE
DESIGNED	SVERDRUP & PARCEL AND ASSOCIATES, INC.	DRAWING NO.
DRAWN	APPROVED	
CHECKED JMN		

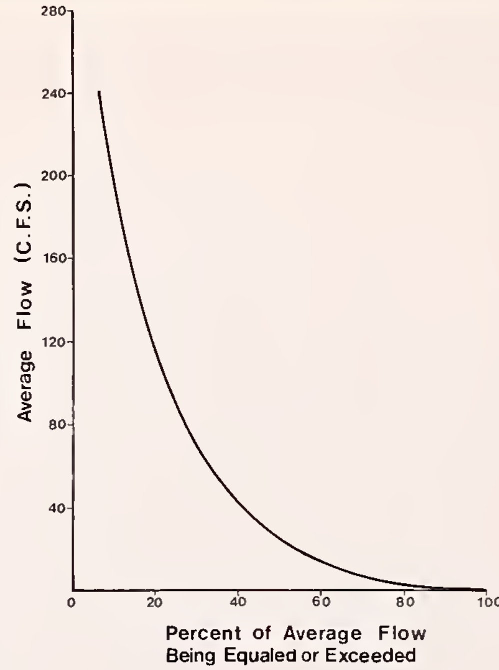
PLATE 3



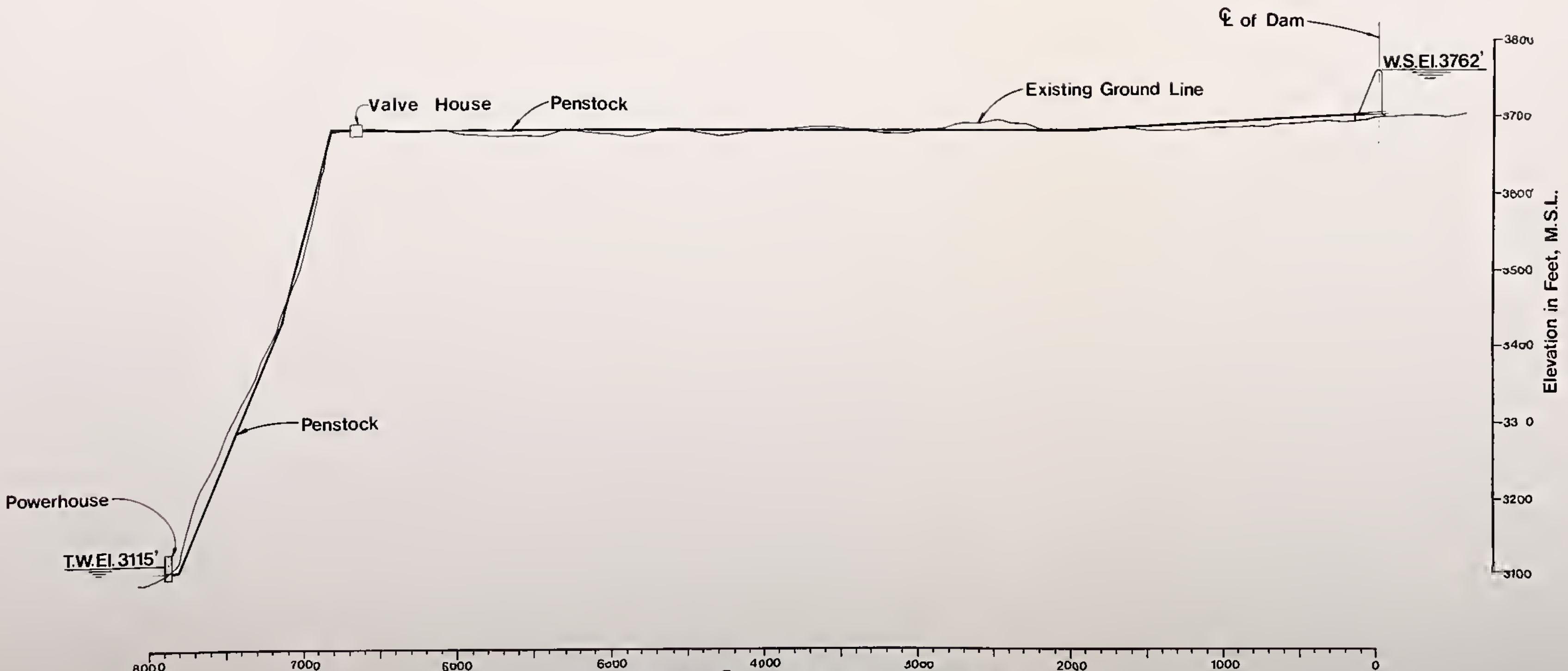
Site Plan
Scale: 1"=1000'



Area-Capacity Curves



Flow Duration Curve



Profile Along ℄ of the Power Conduit
Scale: 1"=500' Horizontal
1"=100' Vertical

REVISION	DATE	DESCRIPTION	BY	APPD

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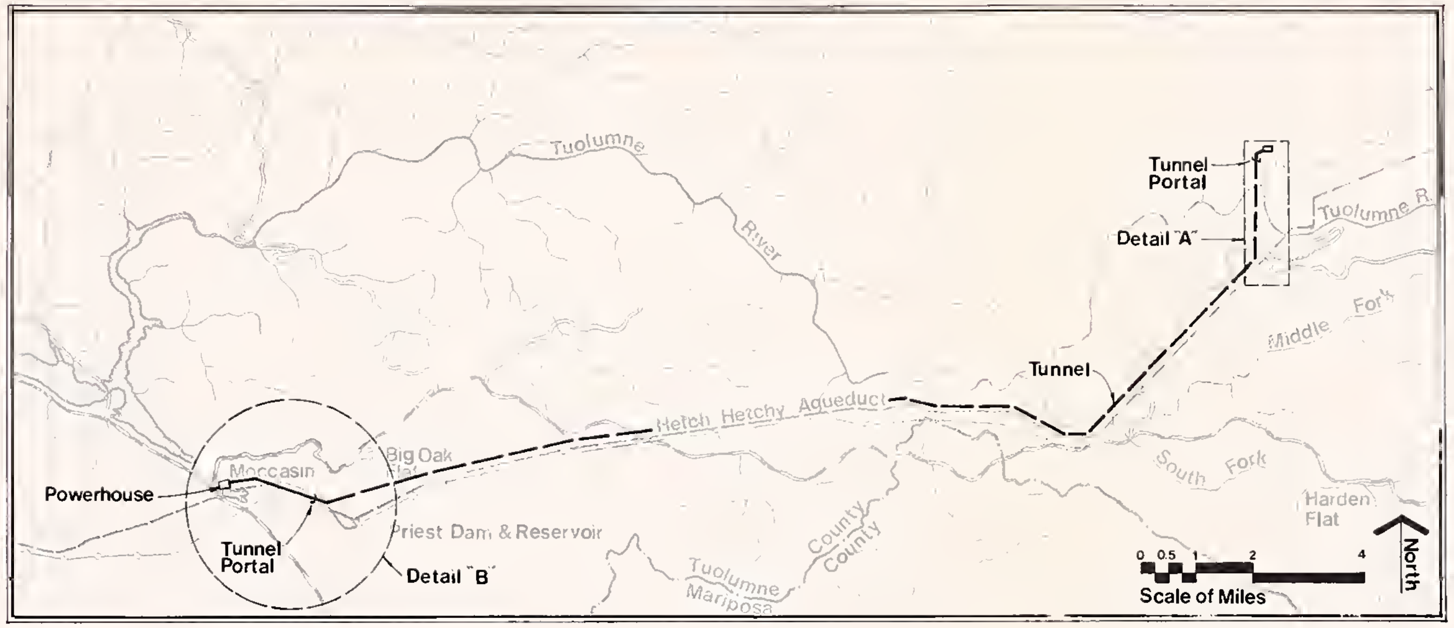
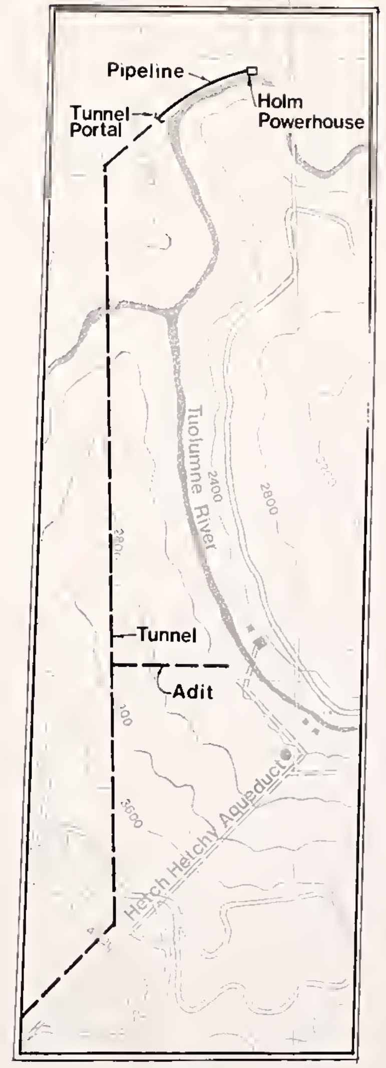
SAN FRANCISCO, CALIFORNIA

HETCH HETCHY WATER AND POWER
SYSTEMWIDE POWER STUDY
PROJECT NO. 5 TAWONGA CAMP PROJECT

SCALE	SUBMITTED	DATE FEB. 1981
DESIGNED	SVERDRUP & PARCEL AND ASSOCIATES, INC.	DRAWING NO.
DRAWN	APPROVED	
CHECKED		



Site Plan



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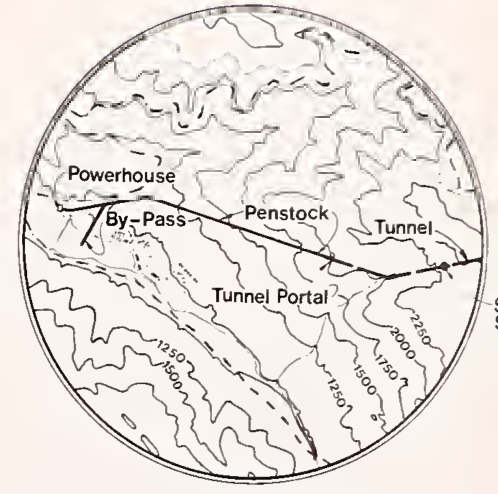

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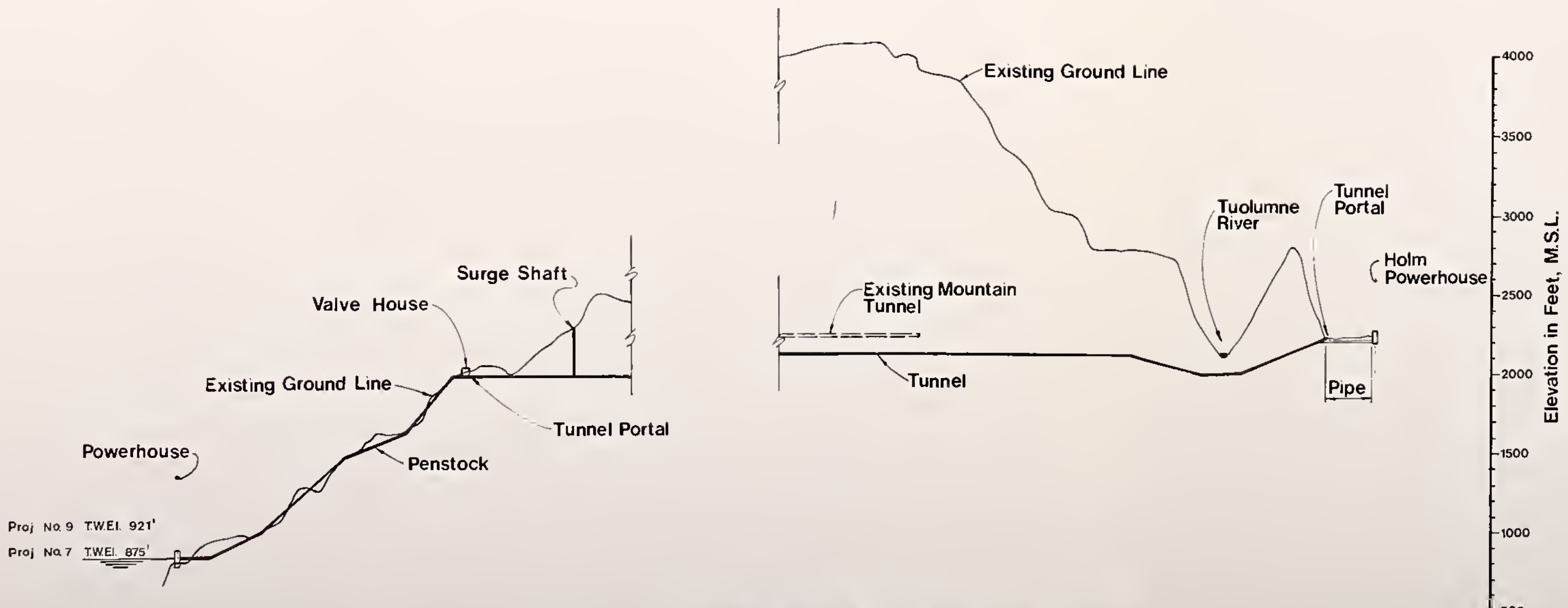
Detail "B" (Project No 9)
Scale 1"=2000'



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1"= 500' Vertical

REVISION	DATE	DESCRIPTION	BY	APPR

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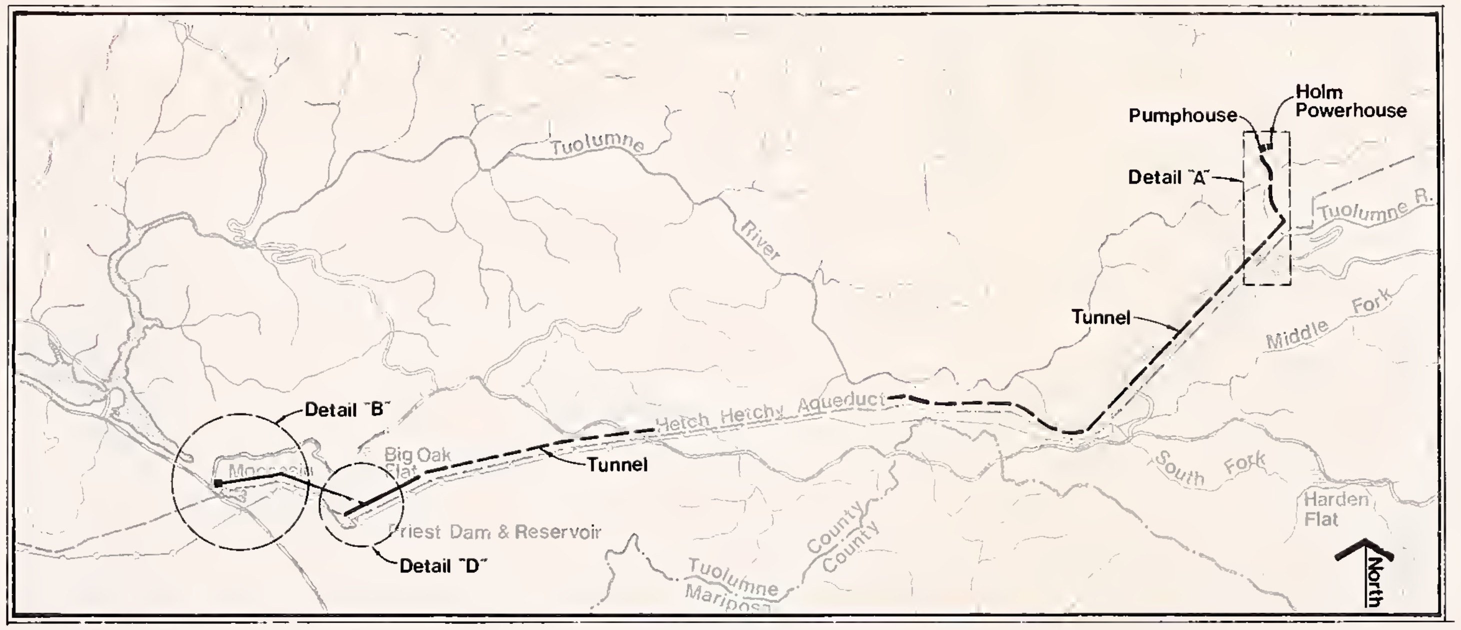
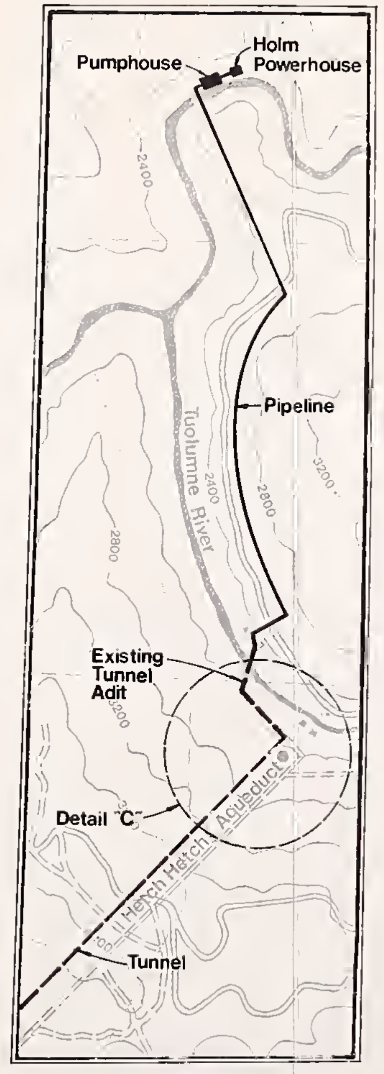
HETCH HETCHY WATER AND POWER
SYSTEMWIDE POWER STUDY
PROJ. NO. 7 LOWER MOCCASIN CREEK P. P.
PROJ. NO. 9 ADDITIONAL MOCCASIN P. P.

SCALE AS SHOWN	SUBMITTED	DATE FEB. 1981	
DESIGNED VMC	SVERDRUP & PARCEL AND ASSOCIATES, INC.	DRAWING NO.	
DRAWN RGL	APPROVED		
CHECKED JMN			



Site Plan



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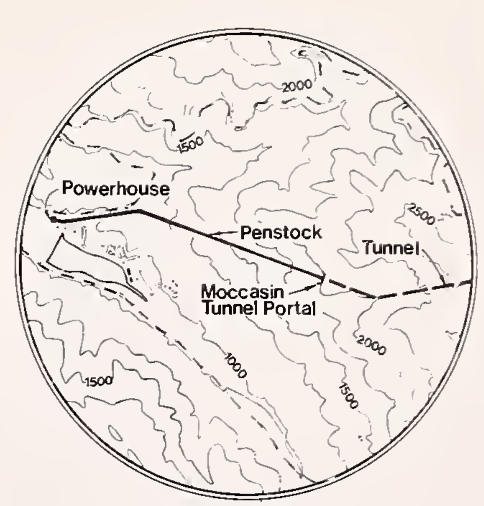

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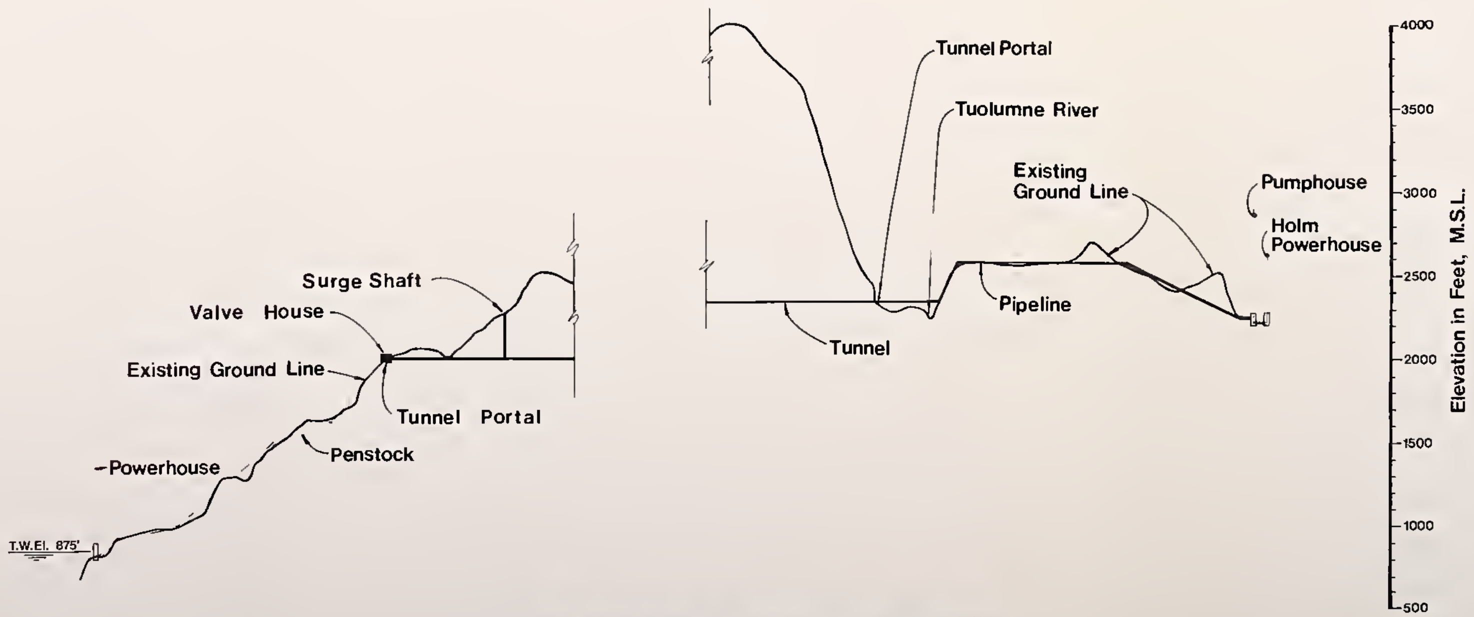

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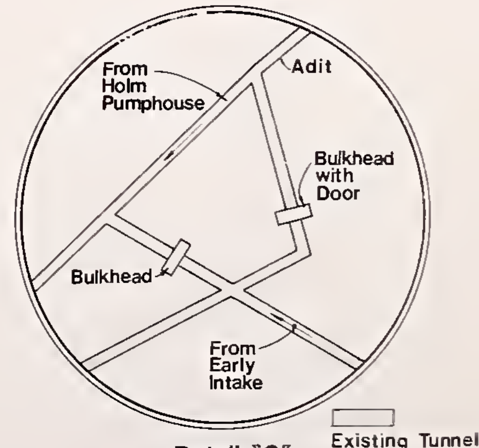

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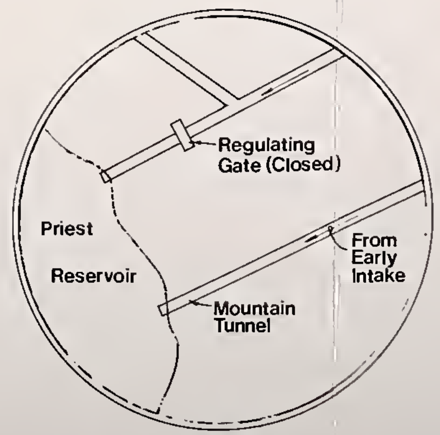
Normal Operating Condition



Detail "D"
Normal Operating Condition

REVISION	DATE	DESCRIPTION	BY	APPD

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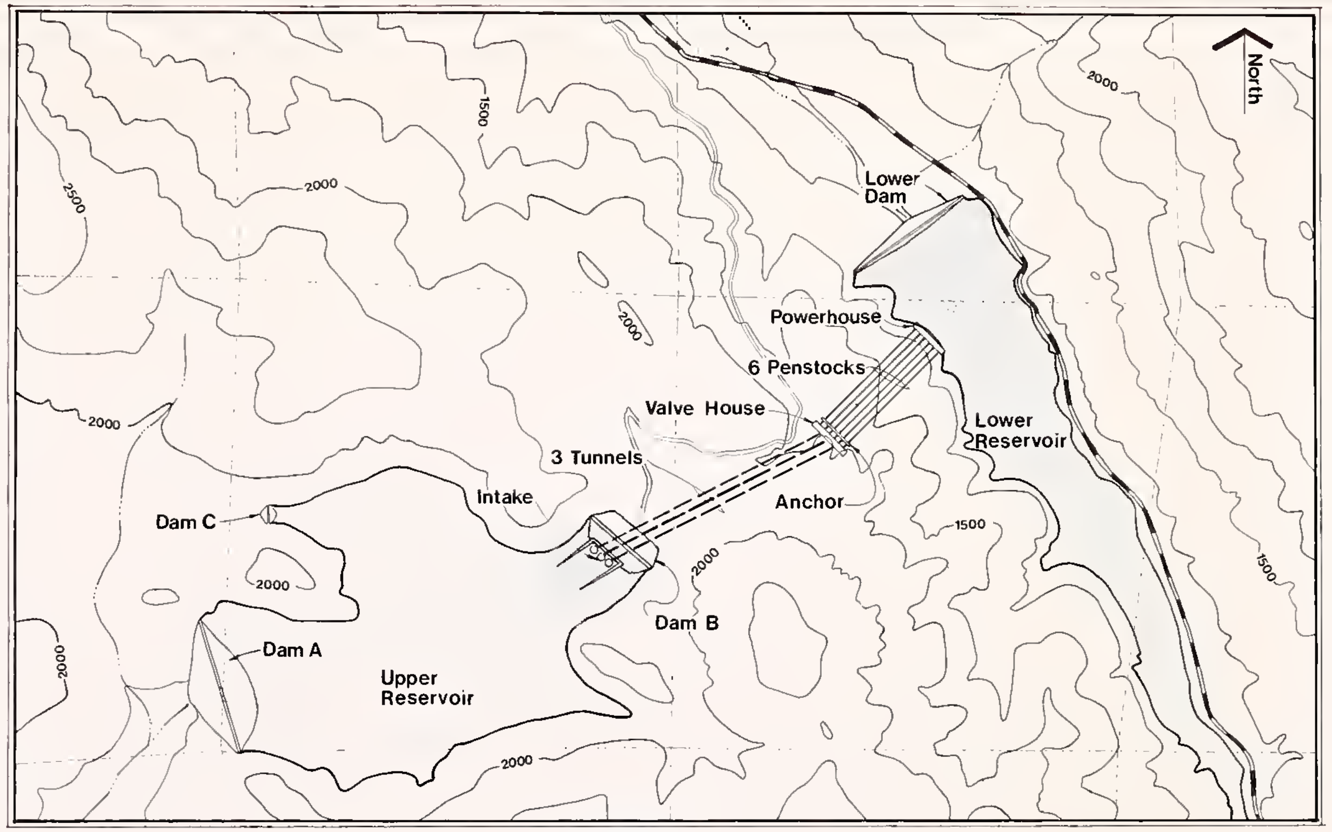
SAN FRANCISCO, CALIFORNIA

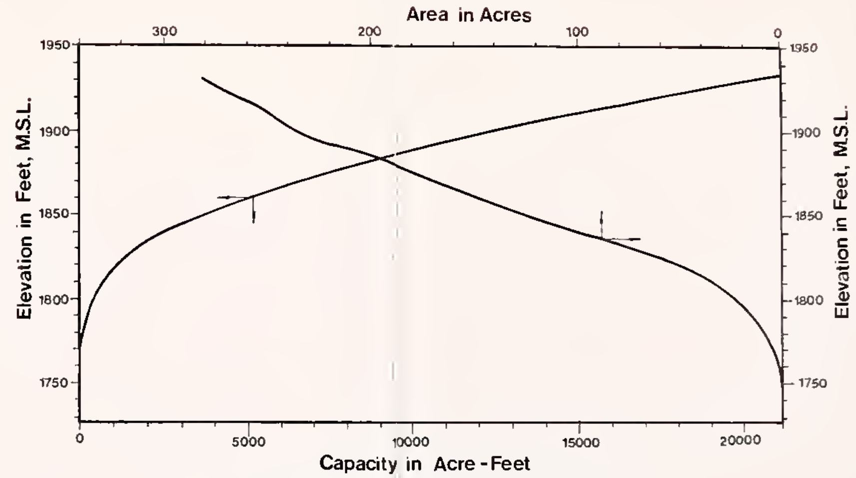
HETCH HETCHY WATER AND POWER
SYSTEMWIDE POWER STUDY

PROJECT NO. 8 HOLM PUMPING PLANT
AND LOWER MOCCASIN CREEK POWER PLANT

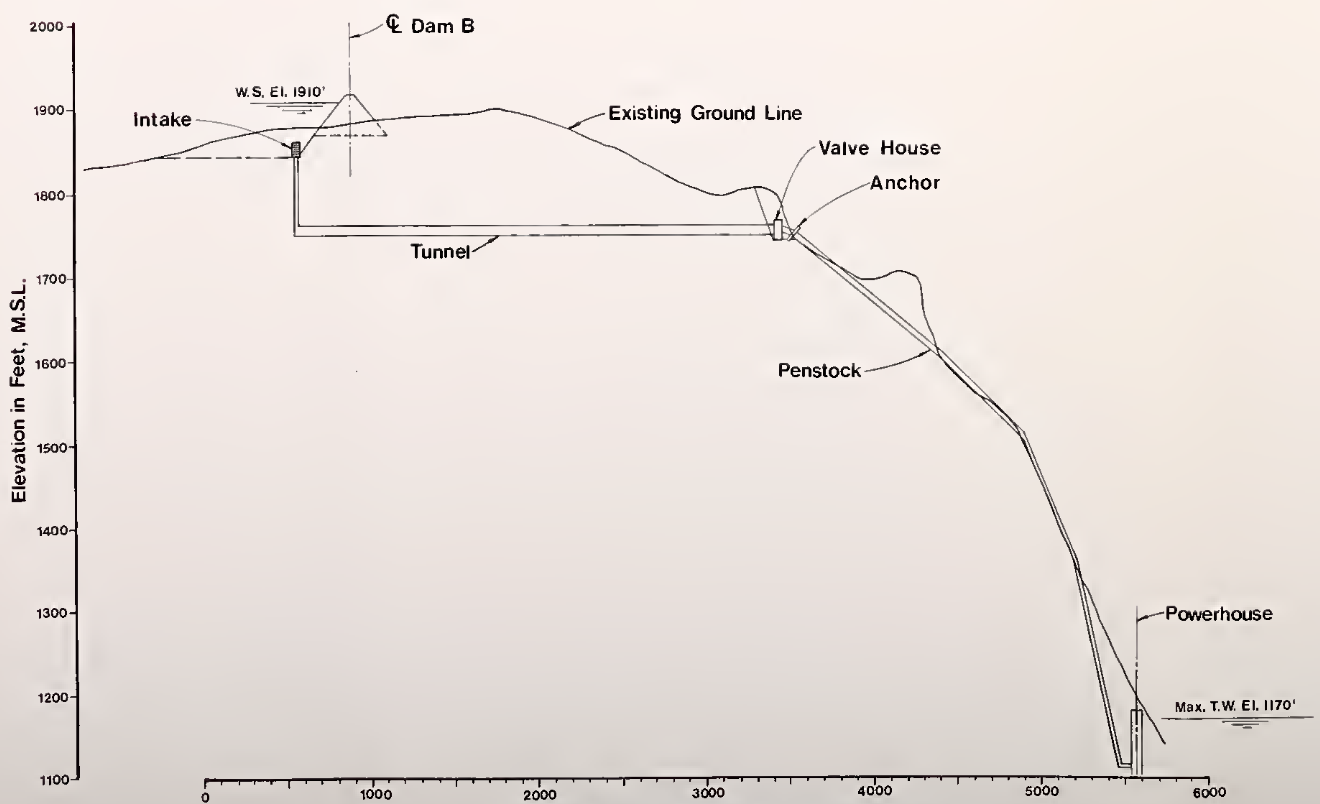
SCALE AS SHOWN
DESIGNED YMC
DRAWN RGL
CHECKED JVN
SUBMITTED SVERDRUP & PARCEL AND ASSOCIATES, INC.
APPROVED
DATE FEB 83
DRAWING NO.



Site Plan
Scale: 1"=1000'



Area-Capacity Curves (Upper Reservoir)
Marsh's Flat Reservoir



Profile Along ℄ of the Power Conduit
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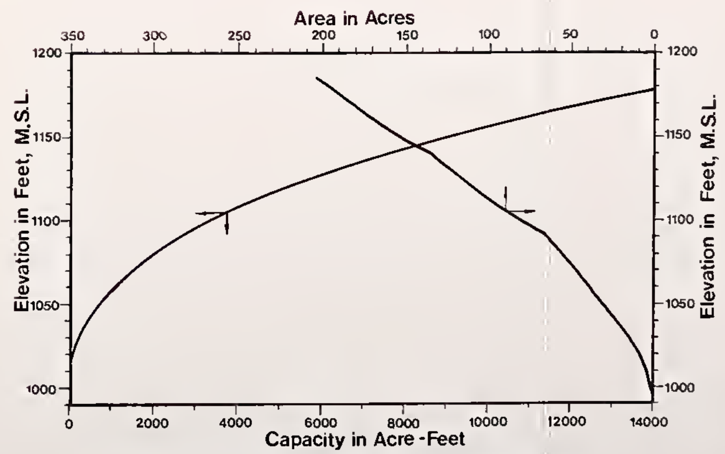
1"=100' Vertical



Area-Capacity Curves (Lower Reservoir)
Moccasin Creek Reservoir

REVISION	DATE	DESCRIPTION	BY	APPD

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SAN FRANCISCO, CALIFORNIA

HETCH HETCHY WATER AND POWER
SYSTEMWIDE POWER STUDY
PROJECT NO. 10 MARSHS FLAT PUMPED-STORAGE SCHEME

SCALE AS SHOWN
DESIGNED RW
DRAWN RGL
CHECKED JMN
SUBMITTED
SVERDRUP & PARCEL AND ASSOCIATES, INC
APPROVED
DATE FEB 75
DRAWING NO.

APPENDIX A

APPENDIX A

Subsequent to issuance of the report to the Public Utility Commission of the City and County of San Francisco, the Commission requested supplementary data showing the impact of releasing water for river rafting purposes from Project No. 9. The Commission also requested that the construction cost and power benefits of the Clavey Project and the combined Clavey-Wards Ferry Projects be updated to the same criteria used to evaluate the other projects for comparative purposes. This Appendix includes the data sheets for the following projects:

Project 9A, Additional Moccasin Powerhouse, if water releases are made to allow 8 full hours of rafting each day during June, July and August.

Project 9B, Additional Moccasin Powerhouse, if Project No. 2 is constructed.

Project 9C, Additional Moccasin Powerhouse, if Project No. 2 is constructed and if water releases are made to allow 8 full hours of rafting each day during June, July and August.

Clavey Project

Clavey-Wards Ferry projects

Project Data Sheet

Project No. 9A   Project Name: Additional Moccasin Power Plant with water released for rafting

General and Technical Data

Location: From Holm Powerhouse to Moccasin Re-regulating Dam

Dam, Type: Existing

Normal Max. W.S. Elevation: 2210

Avg. Operating Head: 1050 Feet

Estimated Design Flow: 830 cfs

Installed Capacity: 63 MW

Number of Units: Two

Type of Turbine: Vertical Shaft Impulse Turbine

Load Factor: 70%

Annual Energy Productions: 383,800,000 kWh

Power Conduit, Type: Power Tunnel

  Inside Diameter: 13 Feet

Penstock, Type: Steel

  Avg. Inside Diameter: 72 Inches

Total Bond Issue: $471,000,000

Project Data Sheet

Project No. 9A Project Name: Additional Moccasin Power Plant with water released for rafting
Bid Date: 1984
On Line: 1988

Annual Cost

(1)	Amortization and Interest Payment (9% interest - 40 years)	39,714,000
(2)	Operation and Maintenance Costs ($5.19/kW \times 1.08^n$)	762,000
(3)	Interim Replacement Costs (1.4% of power plant cost)	449,000
(4)	Administrative and General (39% of (2))	297,000
(5)	Insurance (0.1% of construction cost)	318,000
(6)	Property Tax (approx. 6% net income)	780,000
	TOTAL	42,320,000

Annual Power Benefit

(1)	Capacity ($\$69 \times 1.11^n$)	7,515,000
(2)	Energy ($\$0.054 \times 1.11^n$	47,745,000
	TOTAL	55,260,000
	Benefit-Cost Ratio (B/C)	1.31
	First year's net income	12,940,000

Remarks

No loss in generation at Holm Powerhouse is calculated since generation schedule and construction schedule could be coordinated to result in a two-month downtime when Lake Lloyd is at minimum pool. A $2 million budget item is included in the estimate to enlarge that portion of the existing Mountain Tunnel between Early Intake and the junction with the connecting branch of the new tunnel to carry 1100 cfs.

Project Data Sheet

Project No. 9B

Project Name: Additional Moccasin Power Plant with Proj. #2, O'Shaughnessy Dam raised

General and Technical Data

Location: From Holm Powerhouse to Moccasin Re-regulating Dam

Dam, Type: Existing

Normal Max. W.S. Elevation: 2210

Avg. Operating Head: 1050 Feet

Estimated Design Flow: 830 cfs

Installed Capacity: 63 MW

Number of Units: Two

Type of Turbine: Vertical Shaft Impulse Turbine

Load Factor: 86%

Annual Energy Productions: 476,600,000 kWh

Power Conduit, Type: Power Tunnel

Inside Diameter: 13 Feet

Penstock, Type: Steel

Avg. Inside Diameter: 72 Inches

Total Bond Issue: $471,000,000

Project Data Sheet

Project No. 9B

Project Name: Additional Moccasin Power Plant with Proj. #2, O'Shaughnessy Dam raised

Bid Date: 1984

On Line: 1988

Annual Cost

(1) Amortization and Interest Payment (9% interest - 40 years)	39,714,000
(2) Operation and Maintenance Costs (5.19/kW x 1.08^n)	762,000
(3) Interim Replacement Costs (1.4% of power plant cost)	449,000
(4) Administrative and General (39% of (2))	297,000
(5) Insurance (0.1% of construction cost)	318,000
(6) Property Tax (approx. 6% net income)	1,560,000
TOTAL	43,100,000

Annual Power Benefit

(1) Capacity ($69 x 1.11^n)	10,020,000
(2) Energy ($0.054 x 1.11^n	59,289,000
TOTAL	69,309,000
Benefit-Cost Ratio (B/C)	1.61
First year's net income	26,209,000

Remarks

No loss in generation at Holm Powerhouse is calculated since generation schedule and construction schedule could be coordinated to result in a two-month downtime when Lake Lloyd is at minimum pool. A $2 million budget item is included in the estimate to enlarge that portion of the existing Mountain Tunnel between Early Intake and the junction with the connecting branch of the new tunnel to carry 1100 cfs.

Project Data Sheet

Project No. 9C

Project Name: Additional Moccasin Power Plant with Proj. #2, O'Shaughnessy Dam raised and with water released for rafting

General and Technical Data

Location: From Holm Powerhouse to Moccasin Re-regulating Dam

Dam, Type: Existing

Normal Max. W.S. Elevation: 2210

Avg. Operating Head: 1050 Feet

Estimated Design Flow: 830 cfs

Installed Capacity: 63 MW

Number of Units: Two

Type of Turbine: Vertical Shaft Impulse Turbine

Load Factor: 76%

Annual Energy Productions: 420,040,000 kWh

Power Conduit, Type: Power Tunnel

Inside Diameter: 13 Feet

Penstock, Type: Steel

Avg. Inside Diameter: 72 Inches

Total Bond Issue: $471,000,000

Project Data Sheet

Project No. 9C

Project Name: Additional Moccasin Power Plant with Proj. #2, O'Shaughnessy Dam raised and with water released for rafting
Bid Date: 1984
On Line: 1988

Annual Cost

(1)	Amortization and Interest Payment (9% interest - 40 years)	39,714,000
(2)	Operation and Maintenance Costs (5.19/kW x 1.08^n)	762,000
(3)	Interim Replacement Costs (1.4% of power plant cost)	449,000
(4)	Administrative and General (39% of (2))	297,000
(5)	Insurance (0.1% of construction cost)	318,000
(6)	Property Tax (approx. 6% net income)	1,020,000
	TOTAL	42,560,000

Annual Power Benefit

(1)	Capacity (\$69 x 1.11^n)	7,515,000
(2)	Energy (\$0.054 x 1.11^n	52,298,000
	TOTAL	59,813,000

Benefit-Cost Ratio (B/C)	1.41
First year's net income	17,253,000

Remarks

No loss in generation at Holm Powerhouse is calculated since generation schedule and construction schedule could be coordinated to result in a two-month downtime when Lake Lloyd is at minimum pool. A \$2 million budget item is included in the estimate to enlarge that portion of the existing Mountain Tunnel between Early Intake and the junction with the connecting branch of the new tunnel to carry 1100 cfs.

Project Data Sheet

Project Name: Clavey Project

Bid Date: Mid 1984

On Line: Mid 1988

Annual Cost

(1) Amortization and Interest Payment (9% interest - 40 years)	$ 46,207,000
(2) Operation and Maintenance Costs ($\$5.19/kW \times 1.08^n$)	2,880,000
(3) Interim Replacements Costs (1.4% of power plant cost)	935,000
(4) Administrative and General (39% of (2))	1,123,000
(5) Insurance (0.1% of Construction Cost)	369,000
(6) Property Taxes (approx. 6% net income)	4,800,000
TOTAL	$ 56,314,000

Annual Power Benefit

(1) Capacity ($\$69 \times 1.11^n$)	47,693,000
(2) Energy (0.054×1.11^n)	$ 88,127,000
(3) Total Annual Benefit	$135,820,000
Benefit-Cost Ratio (B/C)	2.41
First year's net income	$ 79,506,000

Evaluation of benefits and costs by Sverdrup & Parcel using the same assumptions for financial analysis as those used in the Systemwide Power Study dated June 1981 by Sverdrup & Parcel.
Source of power generation and cost data:

Summary Report on Update of Project Economics
by R. W. Beck and Associates
February, 1980

Figures shown are for total project costs and benefits. City's interest is 50 percent.

Project Cost Estimate Summary
Bid Date: Mid 1984
On Line: Mid 1988

Project Name: Clavey Project

Major Cost Items	Cost (10^6 x $)(1988)
Preparation	14.83
Dams & Reservoirs	65.43
Penstocks, Tunnels, Tailrace	140.95
Power Plant	66.81
Others Transm. Lines, Swyd, Subs.	33.06
Total Direct Cost	321.08
15% Contingency	48.16
(1) Total Construction Cost	369.24
(2) Engineering and Admin. Costs (12.5%)	46.16
(3) Total Project Cost	415.40
(4) Interest During Construction, 4 yrs. (3) x IDC factor(0.18)	74.77
(5) Total Investment Cost ((3) + (4))	490.17
(6) Reserve Fund *	50.94
(7) Financing Expenses**	5.48
(8) Working Capital***	1.10
(9) Bond Issue	547.69
Say	$548,000,000

* Reserve Fund based on one year's debt service assuming 9%-40-year level
** Based on 1% of total financing
*** Based on 0.2% of total financing

Project Data Sheet
Project Name: Clavey-Wards Ferry
Bid Date: Mid 1984
On Line: Mid 1988

Annual Cost

(1)	Amortization and Interest Payment (9% interest - 40 years)	$ 73,779,000
(2)	Operation and Maintenance Costs ($\$5.19/kW \times 1.08^n$)	4,840,000
(3)	Interim Replacements Costs (1.4% of power plant cost)	2,297,000
(4)	Administrative and General (39% of (2))	1,888,000
(5)	Insurance (0.1% of Construction Cost)	590,000
(6)	Property Taxes (approx. 6% net income)	5,200,000
	TOTAL	$ 88,594,000

Annual Power Benefit

(1)	Capacity ($\$69 \times 1.11^n$)	63,605,000
(2)	Energy (0.054×1.11^n)	$110,039,000
(3)	Total Annual Benefit	$173,644,000
Benefit-Cost Ratio (B/C)		1.96
First year's net income		$ 85,050,000

Evaluation of benefits and costs by Sverdrup & Parcel using the same assumptions for financial analysis as those used in the Systemwide Power Study dated June 1981 by Sverdrup & Parcel.
Source of power generation and cost data:
Summary Report on Update of Project Economics
by R. W. Beck and Associates
February, 1980

Figures shown are for total project costs and benefits. City's interest is 50 percent.

Project Cost Estimate Summary
Bid Date: Mid 1984
On Line: Mid 1988

Project Name: Clavey-Wards Ferry Project

Major Cost Items	Cost (10^6 x $)(1988)
Preparation	30.62
Dams & Reservoirs	153.06
Penstocks, Tunnels, Draft Tube	155.26
Power Plants	164.25
Others (Sales Tax)	10.06
Total Direct Cost	513.09
15% Contingency	76.96
(1) Total Construction Cost	590.05
(2) Engineering and Admin. Costs (12.5%)	73.76
(3) Total Project Cost	663.81
(4) Interest During Construction, 4 yrs. (3) x IDC factor(0.18)	119.41
(5) Total Investment Cost ((3) + (4))	783.30
(6) Reserve Fund *	81.34
(7) Financing Expenses**	8.75
(8) Working Capital***	1.75
(9) Bond Issue	875.14
Say	$875,000,000

* Reserve Fund based on one year's debt service assuming 9%-40-year level
** Based on 1% of total financing
*** Based on 0.2% of total financing